

KOPRI ABSTRACTS

Volume 14 (2022)



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Summary of 2022

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KOPRI ABSTRACTS

Volume 14 (2022)

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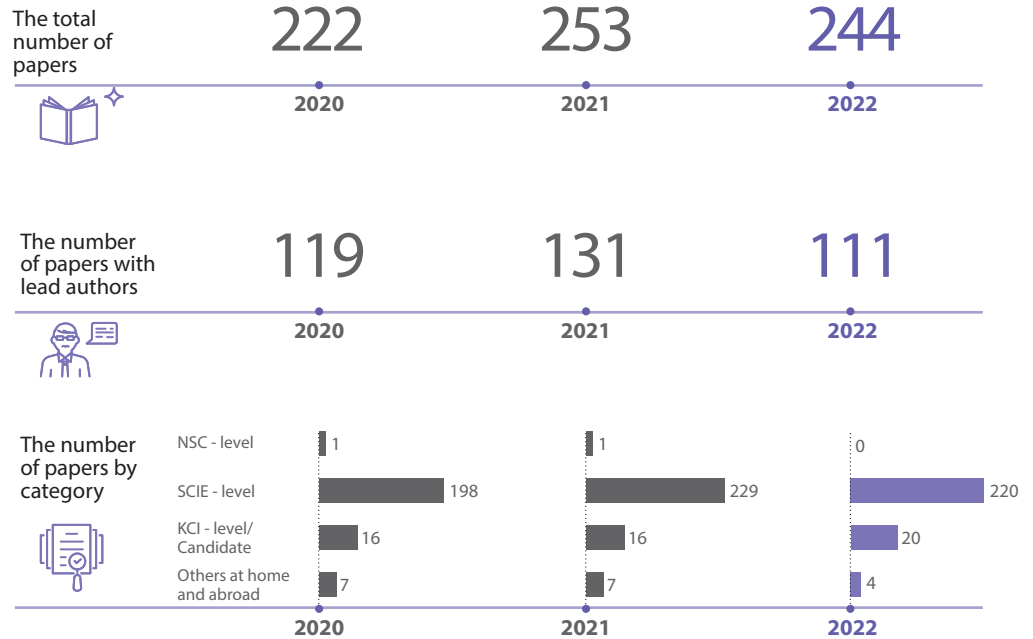
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Summary of 2022 Research Paper Achievement

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

01. Research papers in recent 3 years



02. Collaborative research results at home and abroad



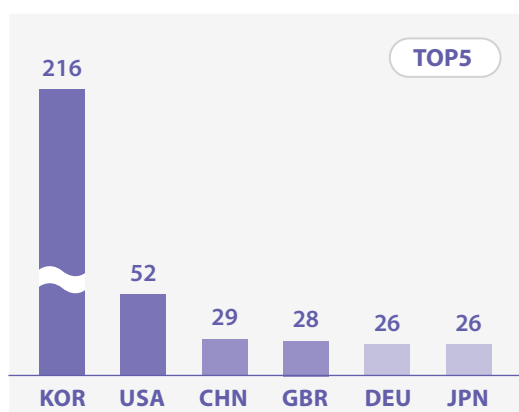
The analysis of papers published in 2022 found that KOPRI conducted collaborative research with individuals or institutions from a total number of **625** institutes and **42** countries.

• Source: Web of Science, Clarivate Analytics



Top 5 countries and number of research papers

Country	Number of records	% of 220
SOUTH KOREA	216	99.0%
USA	52	23.8%
CHINA	29	13.3%
ENGLAND	28	12.8%
GERMANY	26	11.9%
JAPAN	26	11.9%



Top 5 Institutes and number of research papers (Domestic)

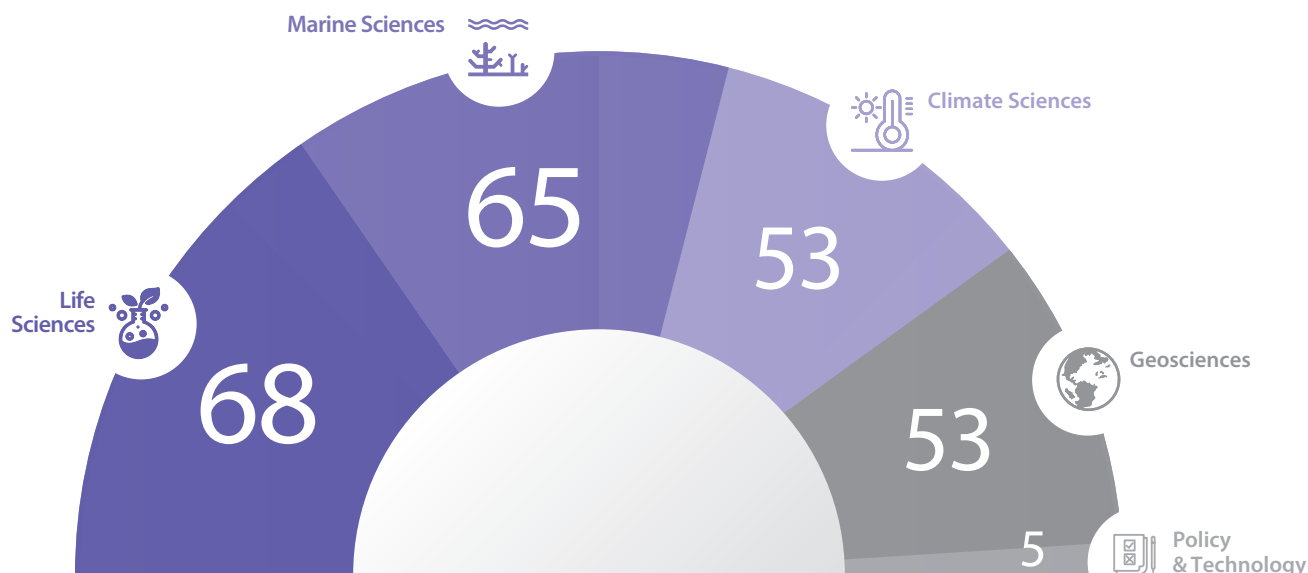
Institute	Number of records	% of 220
KOREA POLAR RESEARCH INSTITUTE (KOPRI)	212	97.2%
UNIVERSITY OF SCIENCE TECHNOLOGY (UST)	45	20.6%
SEOUL NATIONAL UNIVERSITY (SNU)	29	13.3%
KOREA INSTITUTE OF OCEAN SCIENCE TECHNOLOGY (KIOST)	23	10.5%
KOREA UNIVERSITY	21	9.6%
PUSAN NATIONAL UNIVERSITY	15	6.8%

Top 5 Institutes and number of research papers (Abroad)

Institute	Number of records	% of 220
CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS	19	8.7%
UNIVERSITY OF CALIFORNIA SYSTEM	18	8.2%
UDICE FRENCH RESEARCH UNIVERSITIES	16	7.3%
UK RESEARCH INNOVATION UKRI	15	6.8%
NATURAL ENVIRONMENT RESEARCH COUNCIL NERC	14	6.4%

03.
Subject fields of research

Research topics in 2022 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.

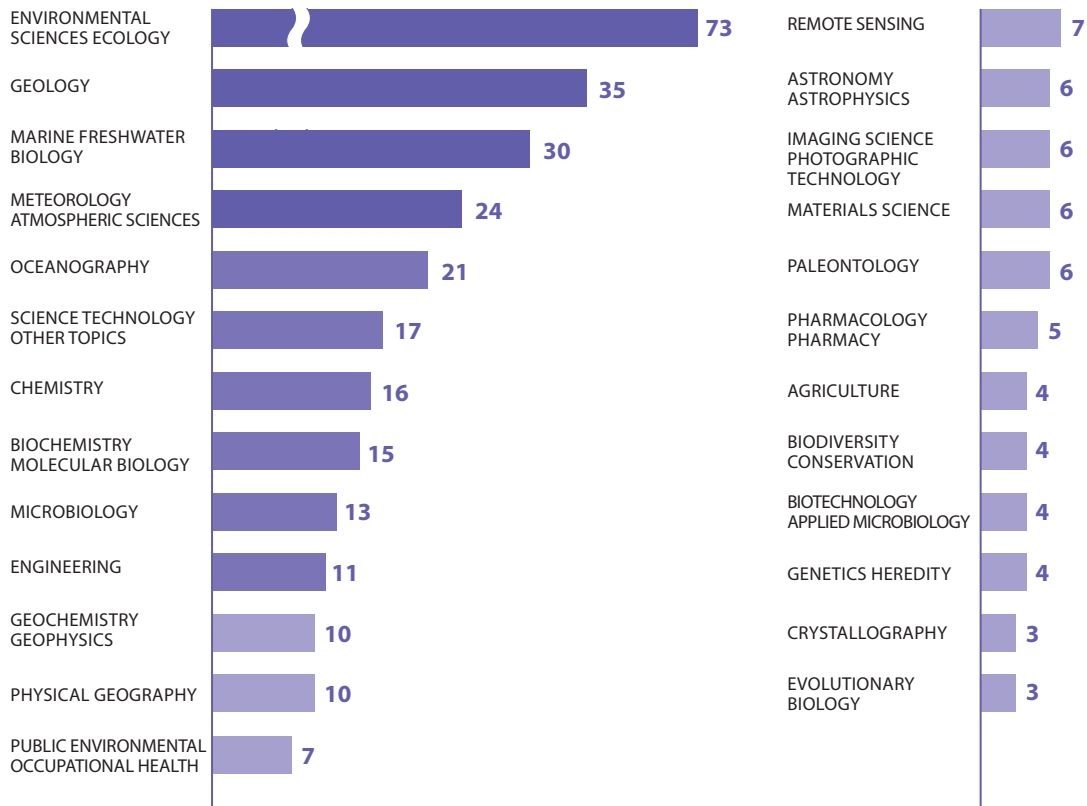
Subject fields of research
in 2022 KOPRI Abstracts

04. WoS Research Areas



Top 25 Subject fields of research

Source: Web of Science, Clarivate Analytics

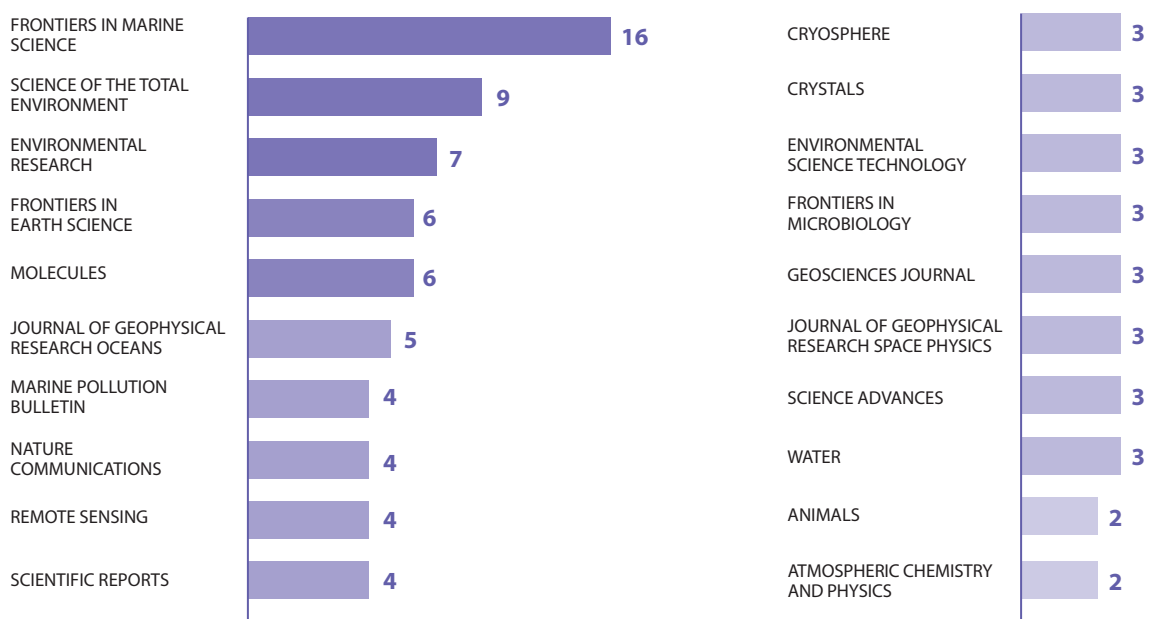


05. Major journals registered



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

Source: Web of Science, Clarivate Analytics



2022년 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.

01. 최근 3년간 연구논문 성과



전체
논문 수

222

253

244

2020

2021

2022



주저자
논문 편수

119

131

111

2020

2021

2022



분류별
논문 수

NSC급

1

1

0

SCIE급

198

229

220

KCI등재/후보

16

16

20

국내외 기타

7

7

4

2020

2021

2022



02. 국내외 공동 연구성과



2022년 WoS에 등재된 SCIE급 논문 220편의 분석 결과, 극지연구소는 국내외 **625개** 기관, **42개** 국가와 공동연구를 수행하였다.

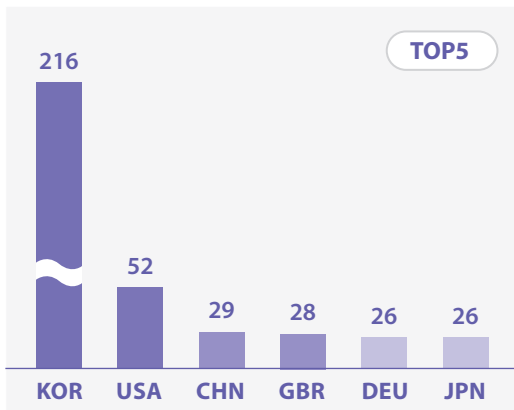


공동연구 수행 국가 TOP 5 및 논문 수

국가	논문 수	%(220 기준)
대한민국	216	99.0%
미국	52	23.8%
중국	29	13.3%
영국	28	12.8%
독일	26	11.9%
일본	26	11.9%

공동연구 수행기관(국내) TOP 5 및 논문 수

기관	논문 수	%(220 기준)
극지연구소	212	97.2%
과학기술연합대학원대학교	45	20.6%
서울대학교	29	13.3%
한국해양과학기술원	23	10.5%
고려대학교	21	9.6%
부산대학교	15	6.8%



공동연구 수행기관(국외) TOP 5 및 논문 수

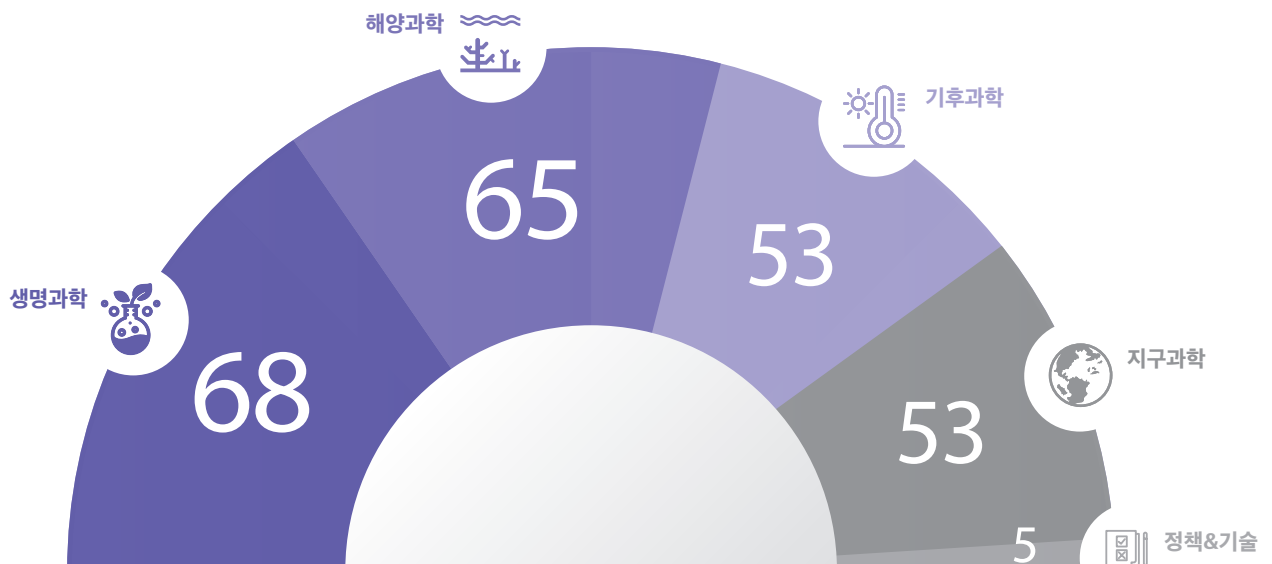
기관	논문 수	%(220 기준)
CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS	19	8.7%
UNIVERSITY OF CALIFORNIA SYSTEM	18	8.2%
UDICE FRENCH RESEARCH UNIVERSITIES	16	7.3%
UK RESEARCH INNOVATION UKRI	15	6.8%
NATURAL ENVIRONMENT RESEARCH COUNCIL NERC	14	6.4%

03. 연구 주제 분야



2022 KOPRI Abstracts 연구 주제는 기후과학, 생명과학, 지구시스템, 해양과학, 정책&기술 분야로 분류하였다. **기후과학**은 대기, 고층대기, 빙하, 고기후, 고환경, 원격탐사 등을 포함하며, **생명과학**은 유전학·유전체학, 생리·생화학, 생물다양성·생태·진화, 생물공학, **지구과학**은 지질, 지구물리, 수중 음향, **해양과학**은 해양학(물리, 화학, 생물학, 지질학)뿐만 아니라 해양환경에 따른 생태학 및 기술 개발 등의 주제를 포함하였다.

2022 KOPRI Abstracts의 연구주제 분야

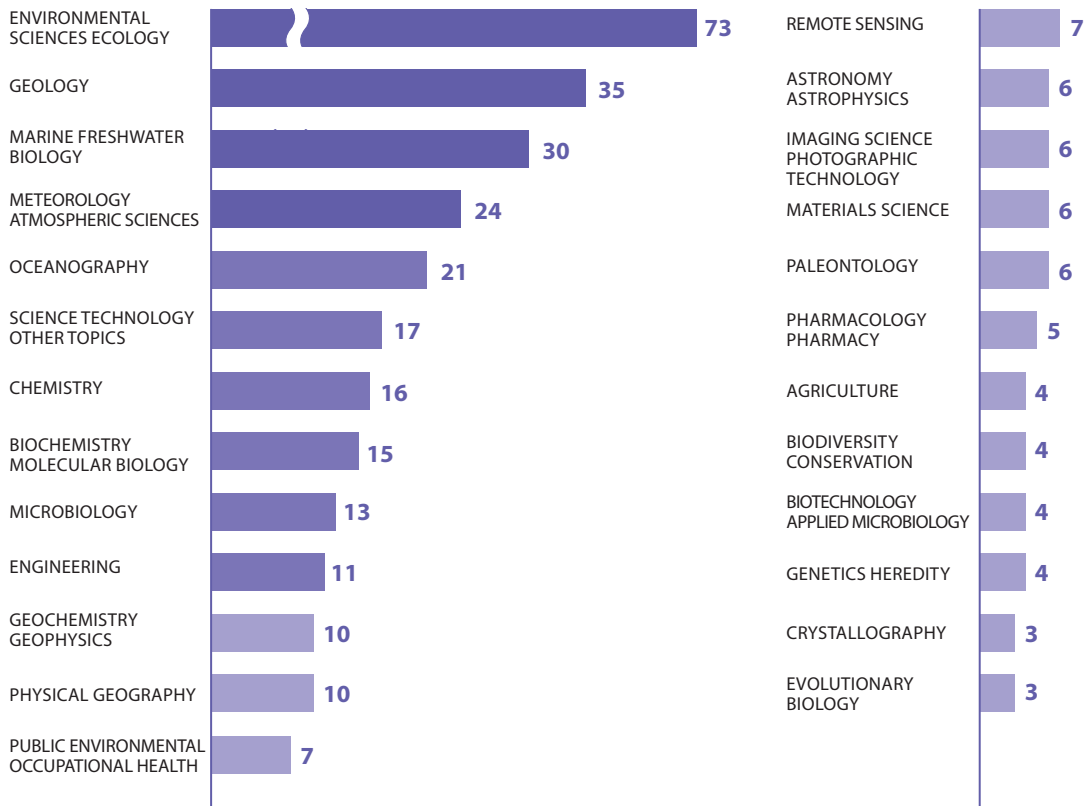


04. WoS 연구 분야



WoS 연구분야 Top 25

· 출처 : Web of Science, Clarivate Analytics

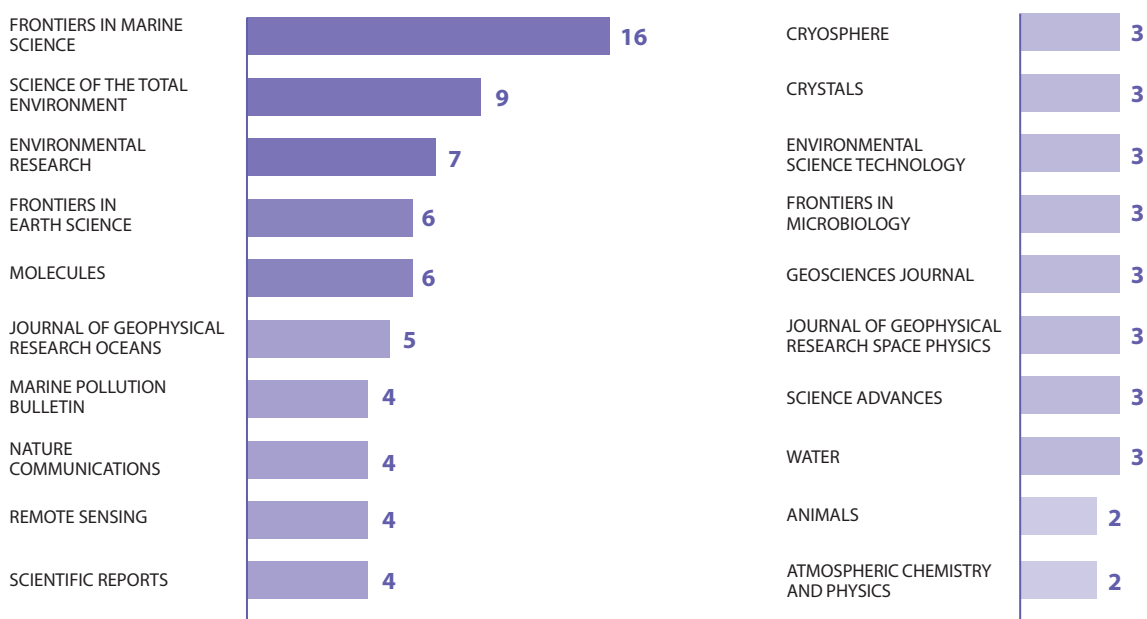


05. 주요 등재 저널



3편 이상 등재된 저널과 논문 수

· 출처 : Web of Science, Clarivate Analytics



NOTICE

1-6 *Physical Geography*

Causes of January Mean Temperature Change Before and After Regime Shift in Korea

Nam, So-Hyun., Baek, Ji-Yun., Yook, Yea-Seul., **Kim, Jeong-Hun.** and 2 others.

Journal of Climate Research. 2022. 17(3): 187-198.

doi: 10.14383/crj.2022.17.3.187

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.

In this study, the cause of the abrupt increase (regime shift) in Korea's January mean temperature around 1986 was analyzed. The results of the EOF analysis show that the inter-annual variability of the northern hemisphere atmospheric circulation in January appear mainly in the Arctic Oscillation (AO) mode, but the spatial pattern of the AO mode changed before and after the regime shift (RS). In particular, before RS, the positive signal of AO did not appear in the North Pacific, whereas after RS, the positive signal was extended from the Aleutian Islands to Korea. In resultant, the warm southerly wind anomaly appeared in Korea, contributing to the abrupt increase of the temperature in Korea. The correlation coefficient pattern between the AO index (AOI) and sea level pressure (SLP) also supports the spatial change of the EOF pattern before and after RS. Thus, the correlation coefficient of January mean temperature and AOI were increased from 0.323 to 0.514 before and after the regime shift. This means that the major factor in the abrupt increase in January temperature is closely related to the change in the AO pattern.

Abstract

keywords: regime shift, AO, correlation coefficient, North Pacific, January temperature

Keywords

Climatic Sciences

1-1 Geology

The ABCflux database: Arctic-boreal CO₂ flux observations and ancillary information aggregated to monthly time steps across terrestrial ecosystems

Virkkala, Anna-Maria., Natali, Susan M., Rogers, Brendan M., Watts, Jennifer D., Savage, Kathleen., Connon, Sara June., Mauritz, Marguerite., Schuur, Edward A. G., Peter, Darcy., Minions, Christina., Nojeim, Julia., Commane, Roisin., Emmerton, Craig A., Goeckede, Mathias., Helbig, Manuel., Holl, David., Iwata, Hiroki., Kobayashi, Hideki., Kolari, Pasi., Lopez-Blanco, Efren., Marushchak, Maija E., Mastepanov, Mikhail., Merbold, Lutz., Parmentier, Frans-Jan W., Peichl, Matthias., Sachs, Torsten., Sonnentag, Oliver., Ueyama, Masahito., Voigt, Carolina., Aurela, Mika., Boike, Julia., Celis, Gerardo., **Chae, Namyi.**, Christensen, Torben R., Bret-Harte, M. Sydonia., Dengel, Sigrid., Dolman, Han., Edgar, Colin W., Elberling, Bo., Euskirchen, Eugenie., Grelle, Achim., Hatakka, Juha., Humphreys, Elyn., Jarveoja, Jarvi., Kotani, Ayumi., Kutzbach, Lars., Laurila, Tuomas., Lohila, Annalea., Mammarella, Ivan., Matsuura, Yojiro., Meyer, Gesa., Nilsson, Mats B., Oberbauer, Steven F., **Park, Sang-Jong.** and 10 others.

Earth System Science Data. 2022. 14(1): 179-208.

doi: 10.5194/essd-14-179-2022

Past efforts to synthesize and quantify the magnitude and change in carbon dioxide (CO₂) fluxes in terrestrial ecosystems across the rapidly warming Arctic-boreal zone (ABZ) have provided valuable information but were limited in their geographical and temporal coverage. Furthermore, these efforts have been based on data aggregated over varying time periods, often with only minimal site ancillary data, thus limiting their potential to be used in large-scale carbon budget assessments. To bridge these gaps, we developed a standardized monthly database of Arctic-boreal CO₂ fluxes (ABCflux) that aggregates in situ measurements of terrestrial net ecosystem CO₂ exchange and its derived partitioned component fluxes: gross primary productivity and ecosystem respiration. The data span from 1989 to 2020 with over 70 supporting variables that describe key site conditions (e.g., vegetation and disturbance type), micrometeorological and

environmental measurements (e.g., air and soil temperatures), and flux measurement techniques. Here, we describe these variables, the spatial and temporal distribution of observations, the main strengths and limitations of the database, and the potential research opportunities it enables. In total, ABCflux includes 244 sites and 6309 monthly observations; 136 sites and 2217 monthly observations represent tundra, and 108 sites and 4092 observations represent the boreal biome. The database includes fluxes estimated with chamber (19% of the monthly observations), snow diffusion (3%) and eddy covariance (78%) techniques. The largest number of observations were collected during the climatological summer (June-August; 32%), and fewer observations were available for autumn (September-October; 25%), winter (December-February; 18%), and spring (March-May; 25%). ABCflux can be used in a wide array of empirical, remote sensing and modeling studies to improve understanding of the regional and temporal variability in CO₂ fluxes and to better estimate the terrestrial ABZ CO₂ budget. ABCflux is openly and freely available online (Virkkala et al., 2021b, <https://doi.org/10.3334/ORNLDAAAC/1934>).

1-2 Environmental Sciences & Ecology; Meteorology & Atmospheric Sciences

Antarctic sea-ice expansion and Southern Ocean cooling linked to tropical variability

Chung, Eui-Seok., Kim, Seong-Joong. and 7 others.

Nature Climate Change. 2022. 12(5): 461-468.

doi: 10.1038/s41558-022-01339-z

A variety of hypotheses, involving sub-ice-shelf melting, stratospheric ozone depletion and tropical teleconnections, have been proposed to explain the observed Antarctic sea-ice expansion over the period of continuous satellite monitoring and corresponding model-observation discrepancy, but the issue remains unresolved. Here, by comparing multiple large ensembles of model simulations with available observations, we show that Antarctic sea ice has expanded due to ocean surface cooling associated with multidecadal variability in the Southern Ocean that temporarily outweighs the opposing forced response. In both observations and model simulations, Southern Ocean multidecadal variability is closely linked to internal variability in the tropics, especially in

the Pacific, via atmospheric teleconnections. The linkages are, however, distinctly weaker in simulations than in observations, accompanied by a marked model-observation mismatch in global warming resulting from potential model bias in the forced response and observed tropical variability. Thus, the forced response dominates in simulations, resulting in apparent model-observation discrepancy.

1-3 *Meteorology & Atmospheric Sciences*

Assessing the consistency of satellite-derived upper tropospheric humidity measurements

Shi, Lei., Schreck Iii, Carl J. J., John, Viju O., **Chung, Eui-Seok**, and 3 others.

Atmospheric Measurement Techniques. 2022. 15(23): 6949-6963.

doi: 10.5194/amt-15-6949-2022

Four upper tropospheric humidity (UTH) datasets derived from satellite sounders are evaluated to assess their consistency as part of the activities for the Global Energy and Water Exchanges (GEWEX) water vapor assessment project. The datasets include UTH computed from brightness temperature measurements of the 183.31 ± 1 GHz channel of the Special Sensor Microwave – Humidity (SSM/T-2), Advanced Microwave Sounding Unit-B (AMSU-B), and Microwave Humidity Sounder (MHS) and from channel 12 of the High-resolution Infrared Radiation Sounder (HIRS). The four datasets are generally consistent in the interannual temporal and spatial variability of the tropics. Large positive anomalies peaked over the central equatorial Pacific region during El Niño events in the same phase with the increase of sea surface temperature (SST). Conversely, large negative anomalies were obtained during El Niño events when the tropical-domain average is taken. The weakened ascending branch of the Pacific Walker circulation in the western Pacific and the enhanced descending branches of the local Hadley circulation along the Pacific subtropics largely contributed to widespread drying areas and thus negative anomalies in the upper troposphere during El Niño events as shown in all four datasets. During a major El Niño event, UTH had higher correlations with the coincident precipitation (0.60 to 0.75) and with 200 hPa velocity potential (−0.42 to −0.64) than with SST (0.37 to 0.49). Due to differences

in retrieval definitions and gridding procedures, there can be a difference of 3%–5% UTH between datasets on average, and larger magnitudes of anomaly values are usually observed in spatial maps of microwave UTH data. Nevertheless, the tropical-domain averaged anomalies of the datasets are close to each other with their differences being mostly less than 0.5%, and more importantly the phases of the time series are generally consistent for variability studies.

1-4 *Environmental Sciences & Ecology; Geology; Remote Sensing; Imaging Science & Photographic Technology*

Assessment of Polar Ionospheric Observations by VIPIR/Dynasonde at Jang Bogo Station, Antarctica: Part 1-Ionospheric Densities

Kim, Eunsol., Jee, Geonhwa., Ham, Young-Bae., Zabotin, Nikolay., **Lee, Changsup., Kwon, Hyuck-Jin.,** Hong, Junseok., **Kim, Jeong-Han.** and Bullett, Terence.

Remote Sensing. 2022. 14(12).

doi: 10.3390/rs14122785

Vertical incidence pulsed ionospheric radar (VIPIR) has been operated to observe the polar ionosphere with Dynasonde analysis software at Jang Bogo Station (JBS), Antarctica, since 2017. The JBS-VIPIR-Dynasonde (JVD) provides ionospheric parameters such as the height profile of electron density with NmF2 and hmF2, the ion drift, and the ionospheric tilt in the bottomside ionosphere. The JBS (74.6°S, 164.2°E) is located in the polar cap, cusp, or auroral region depending on the geomagnetic activity and local time. In the present study, an initial assessment of JVD ionospheric densities is attempted by the comparison with GPS TEC measurements which are simultaneously obtained from the GPS receiver at JBS during the solar minimum period from 2017 to 2019. It is found that the JVD NmF2 and bottomside TEC (bTEC) show a generally good correlation with GPS TEC for geomagnetically quiet conditions. However, the bTEC seems to be less correlated with the GPS TEC with slightly larger spreads especially during the daytime and in summer, which seems to be associated with the characteristics of the polar ionosphere such as energetic particle precipitations and large density irregularities. It is also found that the Dynasonde analysis seems to show some limitations to handle these characteristics of the polar ionosphere and

needs to be improved to produce more accurate ionospheric density profiles especially during disturbed conditions.

keywords: polar ionosphere; VIPIR; Dynasonde; Jang Bogo Station (JBS); Antarctica

1-5 *Environmental Sciences & Ecology; Meteorology & Atmospheric Sciences*

Atmospheric composition in the European Arctic and 30 years of the Zeppelin Observatory, Ny-Ålesund

Platt, Stephen M., Hov, Oystein., Berg, Torunn., Breivik, Knut., Eckhardt, Sabine., Eleftheriadis, Konstantinos., Evangeliou, Nikolaos., Fiebig, Markus., Fisher, Rebecca., Hansen, Georg., Hansson, Hans-Christen., Heintzenberg, Jost., Hermansen, Ove., Heslin-Rees, Dominic., Holmen, Kim., Hudson, Stephen., Kallenborn, Roland., Krejci, Radovan., Krognes, Terje., Larssen, Steinar., Lowry, David., Myhre, Cathrine Lund., Lunder, Chris., Nisbet, Euan., Nizzetto, Pernilla B., **Park, Ki-Tae.**, Pedersen, Christina A., Pfaffhuber, Katrine Aspmo., Rockmann, Thomas., Schmidbauer, Norbert., Solberg, Sverre., Stohl, Andreas., Strom, Johan., Svendby, Tove., Tunved, Peter., Tornkvist, Kjersti., van der Veen., Carina, Vratolis, Stergios., **Yoon, Young Jun.** and 4 others.

Atmospheric Chemistry and Physics. 2022. 22(5): 3321-3369.
doi: 10.5194/acp-22-3321-2022

The Zeppelin Observatory (78.90°N, 11.88°E) is located on Zeppelin Mountain at 472 m a.s.l. on Spitsbergen, the largest island of the Svalbard archipelago. Established in 1989, the observatory is part of Ny-Ålesund Research Station and an important atmospheric measurement site, one of only a few in the high Arctic, and a part of several European and global monitoring programmes and research infrastructures, notably the European Monitoring and Evaluation Programme (EMEP); the Arctic Monitoring and Assessment Programme (AMAP); the Global Atmosphere Watch (GAW); the Aerosol, Clouds and Trace Gases Research Infrastructure (ACTRIS); the Advanced Global Atmospheric Gases Experiment (AGAGE) network; and the Integrated Carbon Observation System (ICOS). The observatory is jointly operated by the Norwegian Polar Institute (NPI), Stockholm University, and the Norwegian Institute for Air Research (NILU). Here we detail the establishment of the Zeppelin Observatory including historical measurements of atmospheric composition in the

European Arctic leading to its construction. We present a history of the measurements at the observatory and review the current state of the European Arctic atmosphere, including results from trends in greenhouse gases, chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs), other trace gases, persistent organic pollutants (POPs) and heavy metals, aerosols and Arctic haze, and atmospheric transport phenomena, and provide an outline of future research directions.

1-6 *Physical Geography*

Causes of January Mean Temperature Change Before and After Regime Shift in Korea

Nam, So-Hyun., Baek, Ji-Yun., Yook, Yea-Seul., **Kim, Jeong-Hun.** and 2 others.

Journal of Climate Research. 2022. 17(3): 187-198.
doi: 10.14383/crj.2022.17.3.187

In this study, the cause of the abrupt increase (regime shift) in Korea's January mean temperature around 1986 was analyzed. The results of the EOF analysis show that the inter-annual variability of the northern hemisphere atmospheric circulation in January appear mainly in the Arctic Oscillation (AO) mode, but the spatial pattern of the AO mode changed before and after the regime shift (RS). In particular, before RS, the positive signal of AO did not appear in the North Pacific, whereas after RS, the positive signal was extended from the Aleutian Islands to Korea. In resultant, the warm southerly wind anomaly appeared in Korea, contributing to the abrupt increase of the temperature in Korea. The correlation coefficient pattern between the AO index (AOI) and sea level pressure (SLP) also supports the spatial change of the EOF pattern before and after RS. Thus, the correlation coefficient of January mean temperature and AOI were increased from 0.323 to 0.514 before and after the regime shift. This means that the major factor in the abrupt increase in January temperature is closely related to the change in the AO pattern.

keywords: regime shift, AO, correlation coefficient, North Pacific, January temperature

1-7 *Environmental Sciences & Ecology***Causes of the Extreme Hot Event on February 9, 2020, in Seymour Island, Antarctic Peninsula**

Bae, Hyo-Jun., Kim, Seong-Joong. and 2 others.

Frontiers in Environmental Science. 2022. 10.

doi: 10.3389/fenvs.2022.865775

On early February of 2020, two consecutive extreme warming events of three day interval at the similar location occurred over the Antarctic Peninsula (AP). The later event, that occurred on February 9, 2020, exhibited a second-highest temperature record of 15.5°C at Marambio station, located on Seymour Island, northeast of the AP. To understand the possible cause of the extreme warming event, we analyzed extreme warming events that occurred on Seymour Island during February over the past 40 years by using observational data from Marambio station alongside the European Center for Medium-Range Weather Forecasts Reanalysis v5 (ERA5) data. The results revealed that the extreme warming event on February 9, 2020 occurred due to the foehn and large-scale horizontal advection. In foehn winds, radiative heating and isentropic drawdown occur simultaneously. The horizontal advection of heat, which leads to extreme warming events, is associated with the strong blocking high in the upper and lower atmosphere. Contrary to the average characteristics of extreme warming events in February over the past 40 years, the extreme warming on February 9, 2020, occurred not only in the AP but also throughout entire West Antarctica.

keywords: hot event, Seymour island, horizontal advection, adiabatic warming, isentropic drawdown

1-8 *Environmental Sciences & Ecology; Meteorology & Atmospheric Sciences***Changes in aerosol particle composition during sea fog formation events in the sea ice regions of the Arctic Ocean**Zhao, Shuhui., Yan, Jinpei., Lin, Qi., Yao, Lei., **Park, Keyhong., Jung, Jinyoung.** and 8 others.*Atmospheric Environment*. 2022. 272.

doi: 10.1016/j.atmosenv.2022.118943

Water soluble ions (WSIs) of aerosol particles is one of the important parameters to study the aerosol-fog

interactions. To study the changes of aerosol WSIs during sea fog events, hourly real-time measurements of WSIs (Na^+ , K^+ , Mg^{2+} , Ca^{2+} , MSA^- , Cl^- , NO_3^- , and SO_4^{2-}) in total suspended aerosol particles (TSP) were conducted in the atmosphere over Arctic Ocean ice floe regions from August 1 to 12, 2017, when the sea fog events were frequently observed. There were significant differences in Na^+ , Cl^- , Mg^{2+} , methanesulfonic acid (MSA^-), sea salt sulfate (ss-SO_4^{2-}) and non-sea salt sulfate (nss-SO_4^{2-}) ions during sea fog events vs. non-sea fog periods. The mass concentrations of sea salt ions, such as Na^+ , Mg^{2+} , Cl^- and ss-SO_4^{2-} , clearly increased before the occurrence of sea fog and then decreased substantially with the formation of sea fog; however, nss-SO_4^{2-} levels did not decrease but remained high during the sea fog processes. These results suggest that sea salt aerosol particles were more likely to serve as condensation nuclei for fog and could be more effectively removed by sea fog than nss-SO_4^{2-} particles. MSA^- only combined with sea salt particles, which were likely to serve as condensation nuclei and be removed by sea fog. Condensation may be the primary factor leading to the reduction of sea salt ions during the sea fog periods, while other factors like the presence of dense sea ice and long-range transport input may also affect the decreasing rate

keywords: Sea fog; Aerosol; Arctic ocean; Sea salt aerosol; Non-sea salt sulfate (nss-SO_4^{2-})

1-9 *Environmental Sciences & Ecology; Meteorology & Atmospheric Sciences***Characteristics of Lightning Electromagnetic Fields Produced by Antarctica Storms**Mohammad, Sulaiman Ali., Ahmad, Mohd Riduan., Abdullah, Mardina., **Park, Sangjong.** and 4 others.*Atmosphere*. 2022. 13(4).

doi: 10.3390/atmos13040588

This paper presents the temporal characteristics of electromagnetic fields produced by cloud-to-ground (CG) lightning flashes associated with Antarctica storms. A total of 51 positive CG (+CG) and 103 negative CG (−CG) flashes have been recorded by a magnetic direction finder (MDF) sensor in King Sejong Station, King George Island. In total, 47 positive and 107 negative return strokes were located, ranges from 32 to 569 km. All CG flashes were detected to occur

over the ocean. The return strokes characteristics include the observations of slow front, fast rising, rise time, and pulse duration with geometric mean values of 3.2, 0.53, 3.21, 13.12, and 67.09 μ s for +CG flashes, while 3.9, 0.57, 3.72, 20.75, and 69.86 μ s for –CG flashes, respectively. Additionally, the average peak currents of +CG and –CG flashes were 4.13 kA and 3.14 kA, respectively. The temporal characteristics of the return strokes of Antarctica storms are comparable to other geographical regions. The smaller peak currents might be due to small magnitude of Antarctica cloud charges when compared to other geographical regions.

keywords: antarctica; cloud-to-ground; electromagnetic; lightning; return stroke

1-10 *Environmental Sciences & Ecology*

Characterization of trace elements and Pb isotopes in PM_{2.5} and isotopic source identification during haze episodes in Seoul, Korea

Lee, Sanghee., Han, Changhee., Ahn, Jinho, Han, Youngcheol., Lee, Ah-hyung., Ro, Seokhyun. and Hong, Sungmin.

Atmospheric Pollution Research. 2022. 13(6).

doi: 10.1016/j.apr.2022.101442

Trace elements in fine particulate matter (PM_{2.5}) exacerbate human health problems owing to exposure to PM_{2.5} and its toxic components. Samples of PM_{2.5} collected in Seoul, Republic of Korea, during typical haze episodes between November 2017 and April 2018, were analyzed for trace elements and Pb isotopes to characterize PM_{2.5} trace elements and their sources. The concentrations of Cu, Zn, As, Cd, Sb, Tl, and Pb showed statistically significant increases with ambient PM_{2.5} levels under their negative relationships with wind speed. High enrichment factor values provided evidence of significant inputs from anthropogenic sources. We assigned the dominant source regions of PM_{2.5} mass and chemical composition during individual sampling periods by coupling the Pb isotopic composition with the air mass back trajectories. The results identified three major categories of domestic, Chinese, and mixed domestic/Chinese source contributions, accounting for about 39%, 38%, and 21%, respectively, during the entire sampling period, which reflects a significant Chinese contribution. Principal component analysis

(PCA) identified the major domestic sources for individual elements: coal/oil combustion and vehicle exhaust (Zn, As, Cd, Sb, Tl, and Pb), non-exhaust traffic emissions (Cu and Sb), and soil/road dust (Fe and Mn). Using a Pb isotopic mixing model, the relative contributions from coal combustion, oil combustion, and vehicle exhaust to associated trace elements were estimated to be $35 \pm 11\%$, $35 \pm 8\%$, and $29 \pm 16\%$, respectively. Our results highlight that beyond addressing climate change, driving the transition from fossil fuels to renewable energy sources in the power, heat, and road transport sectors can help greatly reduce air pollution and achieve healthy environment.

keywords: PM_{2.5}; Trace elements; Pb isotopes; Source apportionment; Mixing model

1-11 *Environmental Sciences & Ecology*

Constraining the effectiveness of inherent tracers of captured CO₂ for tracing CO₂ leakage: Demonstration in a controlled release site

Ju, YeoJin., Gyore, Domokos., Gilfillan, Stuart M. V., Lee, Seong-Sun., Cho, Ilryoung., Ha, Seung-Wook., Joun, Won-Tak., Kang, Hyun-Ji., Do, Hyun-Kwon., Kaown, Dugin., Stuart, Finlay M., Hahm, Doshik., Park, Keyhong. and 2 others.

Science of the Total Environment. 2022. 824.

doi: 10.1016/j.scitotenv.2022.153835

Geological storage of carbon dioxide (CO₂) is an integral component of cost-effective greenhouse gas emissions reduction scenarios. However, a robust monitoring regime is necessary for public and regulatory assurance that any leakage from a storage site can be detected. Here, we present the results from a controlled CO₂ release experiment undertaken at the K-COSEM test site (South Korea) with the aim of demonstrating the effectiveness of the inherent tracer fingerprints (noble gases, $\delta^{13}\text{C}$) in monitoring CO₂ leakage. Following injection of 396 kg CO_{2(g)} into a shallow aquifer, gas release was monitored for 2 months in gas/water phases in and above the injection zone. The injection event resulted in negative concentration changes of the dissolved gases, attributed to the stripping action of the depleted CO₂. Measured fingerprints from inherent noble gases successfully identified solubility-trapping of the injected CO₂ within the shallow aquifer. The $\delta^{13}\text{C}$

within the shallow aquifer could not resolve the level of gas trapping, due to the interaction with heterogeneous carbonate sources in the shallow aquifer. The time-series monitoring of $\delta^{13}\text{C}_{\text{DIC}}$ and dissolved gases detected the stripping action of injected $\text{CO}_{2(\text{g})}$, which can provide an early warning of CO_2 arrival. This study highlights that inherent noble gases can effectively trace the upwardly migrating and fate of CO_2 within a shallow aquifer.

keywords: Carbon capture and storage; monitoring, CO_2 leakage; inherent tracers; noble gas; solubility-trapping

1-12 *Meteorology & Atmospheric Sciences*

Contribution of Ural and Kamchatka Blockings to the Amplified Warm Arctic-Cold Eurasia Pattern under Arctic Sea Ice Loss and Eurasian Cooling

Kim, Seon-Hwa., Sung, Hyun-Joon., **Kim, Seong-Joong.** and 3 others.

Journal of Climate. 2022. 35(13): 4071-4083.

doi: 10.1175/jcli-d-21-0635.1

Previous studies have shown that sea ice loss over the Barents-Kara Seas (BKS) in early winter intensifies surface warming and favors more frequent Ural blocking (UB). Using three different blocking detection methods based on reanalysis and model simulation, we find that the increased occurrences of UB and Kamchatka blocking (KB) over Eurasia are concurrent with both the sea ice loss over the BKS and Eurasian cooling, emphasizing the synergic conditions of sea ice and atmospheric internal variability in facilitating the frequent blocking events. Under the sea ice loss and Eurasian cooling conditions, the KB manifests the strongest surface cold anomaly over northern Eurasia. In contrast, the UB shows either a robust or slightly stronger cold anomaly over Eurasia depending on the conditions above. Consequently, the surface impacts of two regional blockings given the combined conditions of BKS sea ice loss and Eurasian cooling contribute the most to the amplified dipole pattern of Eurasian surface air temperature (SAT). The enhanced dipole pattern shows distinct similarities to the warm Arctic and cold Eurasia (WACE) pattern, previously defined as the second principal mode of winter SAT variability over Eurasia. This implies the role of sea ice loss in reinforcing the internal variability of Eurasian SAT via multiple blocking activities, triggering cold

extremes toward Eurasia. Climate simulations with Community Atmosphere Model version 5 (CAM5) can reproduce the observed linkage among sea ice, blocking, and the WACE pattern.

keywords: Arctic; Sea ice; Blocking; Climate models; Climate variability

1-13 *Meteorology & Atmospheric Sciences*

Decadal shift of the influence of Arctic Oscillation on dust weather frequency in spring over the Middle East during 1974-2019

Sun, Yijie., Mao, Rui., Gong, Dao-Yi., Li, Ying., **Kim, Seong-Joong.** and 3 others.

International Journal of Climatology. 2022. 42(4): 2440-2454.

doi: 10.1002/joc.7375

Dust weather has an impact on human health and climate change in the Middle East. In this study, we examined the influence of the Arctic Oscillation (AO) on spring dust weather frequency over the Middle East at an interannual timescale during 1974-2019. The results show that there was an interdecadal shift of the influence of AO on dust weather frequency in the Middle East, with a correlation coefficient between the AO index and dust weather frequency changing from -0.52 during 1974-1994 period (P1) to 0.49 during 1995-2013 period (P2). During P1, negative correlations between AO index and dust weather frequency were found over the northern Arabian Peninsula, and during P2, positive ones were mostly over the central and southwestern Arabian Peninsula. In the lower and middle troposphere, negative geopotential height anomalies are associated with the negative phase of the AO over South Europe during P1, whereas negative geopotential height anomalies are associated with the positive phase of the AO over Northeast Africa during P2. The negative height anomalies resulted in the occurrence of more low-pressure systems and, thus, dust weather in the Middle East. It is found that the interdecadal shift of the influence of the AO on dust weather was related to an AO-related northward displacement of wave train propagation during P2. Specifically, during P1 period, the northern branch of AO-related wave train dominated over the middle latitudes of the North Atlantic across South Europe to the Arabian Peninsula,

which resulted in the negative height anomaly over South Europe in the lower and middle troposphere. However, during P2 period, the AO-related wave train propagation moved northward, and then, the southern branch of the AO-related wave train dominated over the low latitudes of the North Atlantic across northern Africa to the Arabian Peninsula, which played an important role in the formation of the negative height anomalies over Northeast Africa.

keywords: Arctic Oscillation; dust weather; wave train the Middle East

1-14 *Geology*

Detection of Landfast Sea Ice Near Jang Bogo Antarctic Research Station Using Layer-Stacked Sentinel-1 Interferometric SAR Coherence Images

Kim, Seoung Hee. and Han, Hyangsun.

The journal of Engineering Geology. 2022. 32(2): 271-280.

doi: 10.9720/kseg.2022.2.271

Landfast sea ice forms near coastlines in polar regions. Continuous monitoring of this sea ice is important, as it plays a key role in the marine ecosystem and affects the operation of nearby research stations. This study detected landfast sea ice around Jang Bogo research station in East Antarctica by stacking interferometric coherence images of Sentinel-1 synthetic aperture radar (SAR) data with 6-, 12- and 18-day temporal baselines. A total of 50 landfast sea ice maps were generated covering July 2017 to June 2018. The time series revealed regional differences in the timing of the maximum extent as well as growth rate of landfast sea ice. Overall, detecting landfast sea ice using interferometric SAR coherence seems promisingly feasible; however, limitations remain owing to low backscattering coefficients from new and smooth sea ice surfaces and subtle movements of sea ice in contact with the Campbell Glacier Tongue.

keywords: landfast sea ice; synthetic aperture radar; coherence; Antarctica; Sentinel-1

1-15 *Meteorology & Atmospheric Sciences*

Development of a broadband cavity-enhanced absorption spectrometer for simultaneous measurements of ambient NO₃, NO₂, and H₂O

Nam, Woohui., Cho, Changmin., Perdignes, Begie., **Rhee, Tae Siek.** and Min, Kyung-Eun.

Atmospheric Measurement Techniques. 2022. 15(15): 4473-4487.

doi: 10.5194/amt-15-4473-2022

We describe the characteristics and performances of our newly built broadband cavity-enhanced absorption spectrometer for measurements of nitrate radical (NO₃), nitrogen dioxide (NO₂), and water vapor (H₂O). A customized vibration-resistance cavity layout incorporated with N₂ purging on high-reflection mirror surfaces was implemented with a red light-emitting diode (LED) as a light source. In general, this system achieved over 40 km (up to 101.5 km) of effective light path length at 662 nm from a 0.52 m long cavity. For the accurate NO₃ measurement, the measured absorption spectrum of H₂O was used for simultaneous concentration retrievals with the other species, instead of being treated as interferences to be removed or corrected prior to NO₃ detection. Synthesized N₂O₅ crystals under atmospheric pressure were used for performance tests of linear response and transmission efficiency. From the standard injection experiments of NO₃, NO₂, and H₂O, high linearities were observed ($R^2 \geq 0.9918$). The total NO₃ transmission efficiency through the system was determined to be 81.2% (± 2.9 , 1 σ) within the residence time of 2.59 seconds. The precisions (1 σ) of NO₃, NO₂, and H₂O in 1 Hz measurement from a single pixel on the CCD were 1.41 pptv, 6.92 ppbv, and 35.0 ppmv with uncertainties of 10.8, 5.2, and $\geq 20.5\%$, respectively, mainly from the errors in literature absorption cross-sections. The instrument was successfully deployed aboard the Korean icebreaker R/V *Araon* for an expedition conducted in remote marine boundary layer in the Arctic Ocean during the summer of 2021.

1-16 *Astronomy & Astrophysics* *Geochemistry & Geophysics* *Meteorology & Atmospheric Sciences*

Disappearance of the Polar Cap Ionosphere During Geomagnetic Storm on 11 May 2019

Kwon, Hyuck-Jin., Kim, K. H., **Jee, Geonhwa.**, Seon, J., **Lee,**

Changsup, Ham, Young-Bae, Hong, J., Kim, Eunsol, and 4 others.

Space Weather-the International Journal of Research and Applications. 2022. 20(6).

doi: 10.1029/2022sw003054

Multi-instrument data from Jang Bogo Station (JBS) in Antarctica were utilized to study ionospheric responses to the 11 May 2019 moderate geomagnetic storm. These include Vertical Incident Pulsed Ionospheric Radar (VIPR)/Dynasonde, Fabry-Perot Interferometer (FPI), GPS vertical total electron content (vTEC), and magnetometer. The VIPR/Dynasonde observed long-lasting (>11 hr) severe depletion of the electron density in the F-region ionosphere over JBS. During the depletion interval, GPS TEC also correspondingly decreased, FPI neutral temperature was significantly enhanced, and the polar magnetic field variations showed positive and negative excursions in the Y (east) and Z (vertical) components, respectively. GK-2 A satellite, located ~2.5 hr west of JBS, observed negative magnetic field perturbations in the azimuthal B_D component at geosynchronous orbit during the depletion of ionospheric plasma. Such a B_D perturbation at geosynchronous orbit is due to the field-aligned currents flowing out of the ionosphere. From these observations we suggest that transpolar ionospheric currents connected to the field-aligned currents flowing on a substorm wedge-shaped circuit act as a source of polar atmospheric heating during the moderate geomagnetic storm interval and that elevated heavy molecular gases (O_2 and N_2) by atmospheric heating contribute to the electron density depletion via increased recombination rate.

1-17 Meteorology & Atmospheric Sciences

Dynamics and characteristics of dry and moist heatwaves over East Asia

Ha, Kyung-Ja., Seo, Ye-Won., Yeo, Ji-Hye., Timmermann, Axel., **Chung, Eui-Seok**, and 4 others.

Npj Climate and Atmospheric Science. 2022. 5(1).

doi: 10.1038/s41612-022-00272-4

The increasing frequency of heatwaves over East Asia (EA) is impacting agriculture, water management, and people's livelihood. However, the effect of humidity on high-temperature events has not yet been fully explored. Using observations and future climate

change projections conducted with the latest generation of Earth System models, we examine the mechanisms of dry and moist heatwaves over EA. In the dry heatwave region, anticyclonic circulation has been amplified after the onset of heatwaves under the influence of the convergence of anomalous wave activity flux over northern EA, resulting in surface warming via adiabatic processes. In contrast, the moist heatwaves are triggered by the locally generated anticyclonic anomalies, with the surface warming amplified by cloud and water vapor feedback. Model simulations from phase six of the Coupled Model Intercomparison Project projected display intensification of dry heatwaves and increased moist heatwave days in response to projected increases in greenhouse gas concentrations.

1-18 Science & Technology

East Asian heatwaves driven by Arctic-Siberian warming

Kim, Jeong-Hun, Kim, Seong-Joong, Kim, Joo-Hong, and 2 others.

Scientific Reports. 2022. 12(1).

doi: 10.1038/s41598-022-22628-9

This study investigates the contributing factors of East Asian heatwaves (EAHWs) linked to the Arctic-Siberian Plain (ASP) over the past 42 years (1979-2020). EAHWs are mainly affected by two time scales of variabilities: long-term externally forced and interannual variabilities. The externally forced EAHWs are attributed to the increasing global warming trend, while their interannual variability is related to the circumglobal teleconnection (CGT) and the ASP teleconnection patterns. In addition to the CGT, the Rossby wave energy originating from the ASP propagates to East Asia through the upper troposphere, amplifying the EAHWs. The stationary high pressure in the ASP is generated by vorticity advection in the upper troposphere. Enhanced surface radiative heating and evaporation on the ASP surface increase the specific humidity and temperature, amplifying the thermal high pressure via positive water vapor feedback. Thermal high-pressure amplified by land-atmosphere interactions in the ASP during the peak summer season leads to EAHWs by the propagation of stationary Rossby wave energy. The results indicate that our enhanced understanding of

the ASP teleconnection can improve forecasting of the EAHWs not only on a sub-seasonal time scale but also in future projections of global climate models.

keywords: Arctic-Siberian Plain; East Asian heatwaves; Rossby wave; Teleconnection; heat dome

1-19 *Science & Technology*

Emerging unprecedented lake ice loss in climate change projections

Huang, Lei., Timmermann, Axel., Lee, Sun-Seon., Rodgers, Keith B., Yamaguchi, Ryohei. and **Chung, Eui-Seok.**

Nature Communications. 2022. 13(1).

doi: 10.1038/s41467-022-33495-3

Seasonal ice in lakes plays an important role for local communities and lake ecosystems. Here we use Large Ensemble simulations conducted with the Community Earth System Model version 2, which includes a lake simulator, to quantify the response of lake ice to greenhouse warming and to determine emergence patterns of anthropogenic lake ice loss. Our model simulations show that the average duration of ice coverage and maximum ice thickness are projected to decrease over the next 80 years by 38 days and 0.23 m, respectively. In the Canadian Arctic, lake ice loss is accelerated by the cold-season polar amplification. Lake ice on the Tibetan Plateau decreases rapidly due to a combination of strong insolation forcing and ice-albedo feedbacks. Comparing the anthropogenic signal with natural variability represented by the Large Ensemble, we find that lake ecosystems in these regions may be exposed to no-analogue ice coverage within the next 4-5 decades.

1-20 *Engineering; Meteorology & Atmospheric Sciences*

The Estimation of the Total Freeboard of Arctic Sea Ice in Winter Using Passive Microwave Satellite Measurements

Kim, Jong-Min., Sohn, Byung-Ju., Lee, Sang-Moo., Shi, Hyeon., **Kwon, Young-Joo.**, Kim, Sang-Woo. and **Kim, Hyun-Cheol.**

Journal of Atmospheric and Oceanic Technology. 2022. 39(10): 1611-1627.

doi: 10.1175/jtech-d-21-0105.1

A method for estimating the total freeboard h_f of the sea ice in the Arctic basin was developed in this study. To utilize the dielectric properties of microwave measurements on the sea ice freeboard, we adopted the spectral difference between the microwave frequencies (e.g., the gradient ratio). Satellite lidar altimetry data were utilized as a reference, and two pairs of gradient ratios [GR(36.5, 18.7) and GR(10.7, 6.9)] and an optional brightness temperature for first-year ice [that is, $TB_H(6.9)$] were converted from passive microwave sensors into h_f using the multiple linear regression equation. Using this method, we estimated h_f without direct altimetry measurements. The developed method was evaluated using Operation IceBridge data and the relationship between the regressed h_f and Operation IceBridge h_f had a correlation coefficient R of 0.761 and a nearly unbiased (approximately -0.4 cm) pattern. Because passive microwave measurements are taken in the Arctic daily, the approach presented in this study has the potential to enable daily h_f estimations for the Arctic.

keywords: Arctic Sea Ice; passive microwave satellite; total freeboard

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

Evaluation of Sea Ice Radiative Forcing according to Surface Albedo and Skin Temperature over the Arctic from 1982-2015

Seong, Noh-Hun., **Kim, Hyun-Cheol.**, Choi, Sungwon., Jin, Donghyun., Jung, Daeseong., Sim, Suyoung., Woo, Jongho., Kim, Nayeon., **Seo, Minji.** and 2 others.

Remote Sensing. 2022. 14(11).

doi: 10.3390/rs14112512

Rapid warming of the Arctic has resulted in widespread sea ice loss. Sea ice radiative forcing (SIRF) is the instantaneous perturbation of Earth's radiation at the top of the atmosphere (TOA) caused by sea ice. Previous studies focused only on the role of albedo on SIRF. Skin temperature is also closely related to sea ice changes and is one of the main factors in Arctic amplification. In this study, we estimated SIRF considering both surface albedo and skin temperature using radiative kernels. The annual average net-SIRF, which consists of the sum of albedo-SIRF and temperature-SIRF, was calculated as -54.57 ± 3.84

W/m² for the period 1982–2015. In the net-SIRF calculation, albedo-SIRF and temperature-SIRF made similar contributions. However, the albedo-SIRF changed over the study period by 0.12 ± 0.07 W/m² per year, while the temperature-SIRF changed by 0.22 ± 0.07 W/m² per year. The SIRFs for each factor had different patterns depending on the season and region. In summer, rapid changes in the albedo-SIRF occurred in the Kara and Barents regions. In winter, only a temperature-SIRF was observed, and there was little difference between regions compared to the variations in albedo-SIRF. Based on the results of the study, it was concluded that the overall temperature-SIRF is changing more rapidly than the albedo-SIRF. This study indicates that skin temperatures may have a greater impact on the Arctic than albedo in terms of sea ice surface changes.

keywords: radiative forcing; sea ice change; radiative kernel; surface albedo; skin temperature; arctic

1-22 *Environmental Sciences & Ecology; Meteorology & Atmospheric Sciences*

Factors controlling atmospheric DMS and its oxidation products (MSA and nssSO₄²⁻) in the aerosol at Terra Nova Bay, Antarctica

Becagli, Silvia., Barbaro, Elena., Bonamano, Simone., Caiazza, Laura., di Sarra, Alcide., Feltracco, Matteo., Grigioni, Paolo., Heintzenberg, Jost., Lazzara, Luigi., Legrand, Michel., Madonia, Alice., Marcelli, Marco., Melillo, Chiara., Meloni, Daniela., Nuccio, Caterina., Pace, Giandomenico., **Park, Ki-Tae.** and 5 others.

Atmospheric Chemistry and Physics. 2022. 22(14): 9245-9263.

doi: 10.5194/acp-22-9245-2022

This paper presents the results of simultaneous high time-resolution measurements of biogenic aerosol (methane sulfonic acid (MSA), non-sea salt sulfate nssSO₄²⁻) with its gaseous precursor dimethylsulfide (DMS), performed at the Italian coastal base Mario Zucchelli Station (MZS) in Terra Nova Bay (MZS) during two summer campaigns (2018–2019 and 2019–2020). Data on atmospheric DMS concentration are scarce, especially in Antarctica. The DMS maximum at MZS occurs in December, one month earlier than at other Antarctic stations. The maximum of DMS concentration is connected with the phytoplanktonic senescent phase following the bloom of *Phaeocystis*

antarctica that occurs in the polynya when sea ice opens up. The second plankton bloom occurs in January and, despite the high dimethylsulfoniopropionate (DMSP) concentration in seawater, atmospheric DMS remains low, probably due to its fast biological turnover in seawater in this period. The intensity and timing of the DMS evolution during the two years suggest that only the portion of the polynya close to the sampling site produces a discernible effect on the measured DMS. The closeness to the DMS source area and the occurrence of air masses containing DMS and freshly formed oxidation products allow us to study the kinetic of biogenic aerosol formation and the reliable derivation of the branch ratio between MSA and nssSO₄²⁻ from DMS oxidation that is estimated to be 0.84 ± 0.06 . Conversely, for aged air masses with low DMS content, an enrichment of nssSO₄²⁻ with respect to MSA, is observed. We estimate that the mean contribution of freshly formed biogenic aerosol to PM₁₀ is 17% with a maximum of 56%. The high contribution of biogenic aerosol to the total PM₁₀ mass in summer in this area highlights the dominant role of the polynya on biogenic aerosol formation. Finally, due to the regional and year-to-year variability of DMS and related biogenic aerosol formation, we stress the need for long-term measurements of seawater and atmospheric DMS and biogenic aerosol along the Antarctic coast and in the Southern Ocean.

1-23 *Environmental Sciences & Ecology*

First-year sea ice leads to an increase in dimethyl sulfide-induced particle formation in the Antarctic Peninsula

Jang, Eunho., Park, Ki-Tae., Yoon, Young Jun., Kim, Kitae., Gim, Yeontae., Chung, Hyun Young., Lee, Kitack., **Choi, Jinhee., Park, Jiyeon., Park, Sang-Jong.** and 3 others.

Science of the Total Environment. 2022. 803.

doi: 10.1016/j.scitotenv.2021.150002

Dimethyl sulfide (DMS) produced by marine algae represents the largest natural emission of sulfur to the atmosphere. The oxidation of DMS is a key process affecting new particle formation that contributes to the radiative forcing of the Earth. In this study, atmospheric DMS and its major oxidation products (methanesulfonic acid, MSA; non-sea-salt sulfate, nss-SO₄²⁻) and particle size distributions were

measured at King Sejong station located in the Antarctic Peninsula during the austral spring-summer period in 2018-2020. The observatory was surrounded by open ocean and first-year and multi-year sea ice. Importantly, oceanic emissions and atmospheric oxidation of DMS showed distinct differences depending on source regions. A high mixing ratio of atmospheric DMS was observed when air masses were influenced by the open ocean and first-year sea ice due to the abundance of DMS producers such as pelagic phaeocystis and ice algae. However, the concentrations of MSA and nss-SO_4^{2-} were distinctively increased for air masses originating from first-year sea ice as compared to those originating from the open ocean and multi-year sea ice, suggesting additional influences from the source regions of atmospheric oxidants. Heterogeneous chemical processes that actively occur over first-year sea ice tend to accelerate the release of bromine monoxide (BrO), which is the most efficient DMS oxidant in Antarctica. Model-estimates for surface BrO confirmed that high BrO mixing ratios were closely associated with first-year sea ice, thus enhancing DMS oxidation. Consequently, the concentration of newly formed particles originated from first-year sea ice, which was a strong source area for both DMS and BrO was greater than from open ocean (high DMS but low BrO). These results indicate that first-year sea ice plays an important yet overlooked role in DMS-induced new particle formation in polar environments, where warming-induced sea ice changes are pronounced.

keywords: Dimethyl sulfide; Sulfurous particles; New particle formation; Bromine monoxide; First-Year Sea ice; Antarctic peninsula

1-24 *Engineering; Environmental Sciences & Ecology*

Freeze-Thaw Cycle-Enhanced Transformation of Iodide to Organoiodine Compounds in the Presence of Natural Organic Matter and Fe(III)

Du, Juanshan., **Kim, Kitae.** and 2 others.

Environmental Science & Technology. 2022. 56(2): 1007-1016.

doi: 10.1021/acs.est.1c06747

The formation of organoiodine compounds (OICs) is of great interest in the natural iodine cycle as well as water treatment processes. Herein, we report a

pathway of OIC formation that reactive iodine (RI) and OICs are produced from iodide oxidation in the presence of Fe(III) and natural organic matter (NOM) in frozen solution, whereas their production is insignificant in aqueous solution. Moreover, thawing the frozen solution induces the further production of OICs. A total of 352 OICs are detected by Fourier transform ion cyclotron resonance mass spectrometry in the freeze-thaw cycled reactions of Fe(III)/ I^- /humic acid solution, which are five times as many as OICs in aqueous reactions. Using model organic compounds instead of NOM, aromatic compounds (e.g., phenol, aniline, o-cresol, and guaiacol) induce higher OIC formation yields (10.4-18.6%) in the freeze-thaw Fe(III)/ I^- system than those in aqueous (1.1-2.1%) or frozen (2.7-7.6%) solutions. In the frozen solution, the formation of RI is enhanced, but its further reaction with NOM is hindered. Therefore, the freeze-thaw cycle in which RI is formed in the frozen media and the resulting RI is consumed by reaction with NOM in the subsequently thawed solution is more efficient in producing OICs than the continuous reaction in frozen solution

keywords: iodination; reactions in ice; freeze-concentration effect; humic substances; reactive iodine formation

1-25 *Environmental Sciences & Ecology; Public, Environmental & Occupational Health*

Freezing-enhanced oxidation of iodide by hydrogen peroxide in the presence of antifreeze proteins from the Arctic yeast *Leucosporidium* sp. AY30

Kim, Bomi., Do, Hackwon., Kim, Bo-Mi., Lee, Jun Hyuck., Kim, Sanghee., Kim, Eun Jae., Lee, Jungeun., Cho, Sung Mi. and **Kim, Kitae.**

Environmental Research. 2022. 212.

doi: 10.1016/j.envres.2022.113233

Ice-binding proteins (IBPs), originating from Arctic or Antarctic microorganisms, have freeze-inhibiting characteristics, allowing these organisms to survive in polar regions. Despite their significance in polar environments, the mechanism through which IBPs affect the chemical reactions in ice by controlling ice crystal formation has not yet been reported. In this study, a new mechanism for iodide (I^-) activation into triiodide (I_3^-), which is the abundant iodine species in

seawater, by using hydrogen peroxide (H_2O_2) in a frozen solution with IBPs was developed. A significant enhancement of I^- activation into I_3^- was observed in the presence of Arctic-yeast-originating extracellular ice-binding glycoprotein (LeIBP) isolated from *Leucosporidium* sp. AY30, and a further increase in the I_3^- concentration was observed with the introduction of H_2O_2 to the frozen solution (25 times higher than in the aqueous solution after 24 h of reaction). The reaction in the ice increased with an increase in LeIBP concentration. The *in-situ* pH measurement in ice using cresol red (CR) revealed protons accumulated in the ice grain boundaries by LeIBP. However, the presence of LeIBP did not influence the acidity of the ice. The enhanced freeze concentration effect of H_2O_2 by LeIBP indicated that larger ice granules were formed in the presence of LeIBP. The results suggest that LeIBP affects the formation and morphology of ice granules, which reduces the total volume of ice boundaries throughout the ice. This leads to an increased local concentration of I^- and H_2O_2 within the ice grain boundaries. IBP-assisted production of gaseous iodine in a frozen environment provides a previously unrecognized formation mechanism of active iodine species in the polar regions.

keywords: Chemical reaction in ice; Freeze concentration; Hydrogen peroxide; Ice binding protein; Iodine chemistry

freezing/Oxone system significantly accelerated the degradation of 4-CP. Various analytical characterizations and pH measurements of the frozen solution suggested that the enhanced degradation of 4-CP in the freezing/Oxone/ Cl^- system could be because Cl^- , Oxone, and protons are concentrated in the liquid brine upon freezing. This process subsequently facilitates the formation of hypochlorous acid (HOCl) as a secondary oxidant. The positive effect of Cl^- was observed under widely varying conditions (i.e., $[\text{Cl}^-] = 25\text{--}1000\mu\text{M}$, $\text{pH}_i = 3\text{--}11$, and freezing temperature = from -10 to -30°C), and the freezing/Oxone/ Cl^- system described herein successfully degraded all 12 tested organic pollutants. In addition, outdoor freezing experiments carried out on winter days confirmed the successful performance of the freezing/Oxone/ Cl^- system without the requirement for electrical energy.

keywords: Advanced oxidation process; Chemical reaction in frozen solution; Freezing-induced water treatment; Freeze concentration effect; Free chlorine production

1-26 Engineering

Freezing-induced activation of the binary chloride-Oxone system to free chlorine and its application in water treatment

Kim, Kitae. Le, Nhat Thi Hong., Nguyen, Anh Quoc Khuong., **Ahn, Yong-Yoon.**, **Kim, Bomi.** and 3 others.

Chemical Engineering Journal. 2022. 428.

doi: 10.1016/j.cej.2021.131134

Accelerated chemical reactions in frozen solutions can be applied in the degradation of organic pollutants in water. Herein we propose a novel freezing system that enables the degradation of various organic compounds in a frozen solution. Although the degradation of 4-chlorophenol (4-CP) by Oxone as the sole primary oxidant did not take place in aqueous solutions (25°C) regardless of the presence of chloride ions (Cl^- , micromolar levels) and only took place to a minor extent in frozen solutions (-20°C) in the absence of Cl^- , the addition of Cl^- (micromolar levels) to the

1-27 Science & Technology

Influence of the recent winter Arctic sea ice loss in short-term simulations of a regional atmospheric model

Cho, Heeje., Kug, Jong-Seong. and **Jun, Sang-Yoon.**

Scientific Reports. 2022. 12(1).

doi: 10.1038/s41598-022-12783-4

Notable changes in the wintertime Arctic atmospheric circulation have occurred over the last few decades. Despite its importance in understanding the recent changes in the Northern Hemisphere midlatitude climate, it remains unclear whether and how these changes are affected by recent Arctic sea ice loss. In this study, a regional scale model is used to separate the direct sea ice influence from the natural variability of large-scale atmospheric circulation. Results show that, in response to sea ice loss, the increase of geopotential height in the mid-to-upper troposphere is robust across the simulations, but the magnitude of the response is highly dependent on the background state of the atmosphere. In most cases the sea ice loss-induced atmospheric warming is trapped near the surface due to the high vertical stability of winter Arctic lower troposphere, accordingly, resulting in a

small response of geopotential height. However, when a low-pressure system is located over the Barents Sea, the relatively weak stability allows an upward transport of the surface warming, causing a significantly larger geopotential height increase. This strong state-dependence of atmospheric response which is also found in recent studies using global-scale model experiments, highlights the importance of accurately representing the atmospheric background state for numerical model assessments of sea ice influence.

keywords: Arctic sea-ice; Polar WRF; short-term Arctic atmospheric response

1-28 *Meteorology & Atmospheric Sciences*

Intraseasonal Melting of Northern Barents Sea Ice Forced by Circumpolar Clockwise-Propagating Atmospheric Waves during Early Summer

Yang, Jing., Li, Siyu., Zhu, Tao., Qi, Xin., Liu, Jiping., **Kim, Seong-Joong.** and Gong, Daoyi.

Journal of Climate. 2022. 35(17): 5703-5718.

doi: 10.1175/jcli-d-21-0538.1

Arctic sea ice intraseasonal variation (ISV) is crucial for understanding and predicting atmospheric subseasonal variations over the middle and high latitudes but unclear. Sea ice concentration (SIC) over the northern Barents Sea (NBS) features large ISV during the melting season (April-July). Based on the observed SIC, this study finds that the NBS SIC ISV in the melting season is dominated by 30-60-day periodicity. The composite analysis, using 34 significant 30-60-day sea ice melting events during 1989-2017, demonstrates that 30-60-day circumpolar clockwise-propagating atmospheric waves (CCPW) are concurrent with the NBS SIC ISV, which features zonal wavenumber 1 along 65 degrees N and a typical quasi-barotropic structure. Further analysis finds that the 30-60-day surface air temperature (SAT) evidently leads the SIC variations by nearly 6 days over the NBS, which is primarily caused by low-level meridional thermal advection linked with the 30-60-day CCPW. The positive anomalies of the downward sensible heat and longwave radiative fluxes, caused by the increased SAT and atmospheric moisture, play the dominant roles in melting the sea ice on the 30-60-day time scale over the NBS. The increased atmospheric moisture is mainly ascribed to the increased horizontal moisture

advection influence by the 30-60-day CCPW. This study strongly suggests that the atmospheric ISV is a crucial precursor for NBS sea ice intraseasonal changes in boreal summer, and more accurate subseasonal predictions of atmospheric circulation, temperature, and moisture are indispensable for improving sea ice subseasonal prediction over the Arctic region. Significance Statement Northern Barents Sea (NBS) sea ice intraseasonal variation (ISV) is crucial for understanding mid- to high-latitude climate variations as well as new trans-Arctic shipping predictions but lacks solid knowledge. This study found that the 30-60-day variation is the dominant ISV periodicity of NBS sea ice change during summer, which is essentially modulated by circumpolar clockwise-propagating atmospheric waves. The atmospheric wave-induced meridional thermal advection modulates the surface temperature and atmospheric moisture, causes the changes of downward sensible heat and longwave radiative fluxes, and eventually dominantly regulates the 30-60-day sea ice variations. The mechanism of sea ice ISV strongly suggests that accurately predicting the atmospheric fields is indispensable for obtaining more accurate sea ice subseasonal prediction.

keywords: Atmosphere; Sea ice; Intraseasonal variability

1-29 *Environmental Sciences & Ecology*

Leaching material from Antarctic seaweeds and penguin guano affects cloud-relevant aerosol production

Dall'Osto, Manuel., Sotomayor-Garcia, Ana., Cabrera-Brufau, Miguel., Berdalet, Elisa., Vaque, Dolors., Zeppenfeld, Sebastian., Van Pinxteren, Manuela., Herrmann, Hartmut., Wex, Heike., Rinaldi, Matteo., Paglione, Marco., Beddows, David., Harrison, Roy., Avila, Conxita., Martin-Martin, Rafael P., **Park, Jiyeon.** and Barbosa, Andres.

Science of the Total Environment. 2022. 831.

doi: 10.1016/j.scitotenv.2022.154772

Within the Southern Ocean, the greatest warming is occurring on the Antarctic Peninsula (AP) where clear cryospheric and biological consequences are being observed. Antarctic coastal systems harbour a high diversity of marine and terrestrial ecosystems heavily influenced by Antarctic seaweeds (benthonic macroalgae) and bird colonies (mainly penguins).

Primary sea spray aerosols (SSA) formed by the outburst of bubbles via the sea-surface microlayer depend on the organic composition of the sea water surface. In order to gain insight into the influence of ocean biology and biogeochemistry on atmospheric aerosol, we performed in situ laboratory aerosol bubble chamber experiments to study the effect of different leachates of biogenic material - obtained from common Antarctic seaweeds as well as penguin guano - on primary SSA. The addition of different leachate materials on a seawater sample showed a dichotomous effect depending on the leachate material added - either suppressing (up to 52%) or enhancing (22-88%) aerosol particle production. We found high ice nucleating particle number concentrations resulting from addition of guano leachate material. Given the evolution of upper marine polar coastal ecosystems in the AP, further studies on ocean-atmosphere coupling are needed in order to represent the currently poorly understood climate feedback processes.

keywords: Sea spray aerosols; Antarctic; Sea ice-atmospheric interactions; Atmospheric marine biogeochemistry; CATCH; BEPSII; SOLAS

1-30 *Biochemistry & Molecular Biology; Chemistry*

Lead Isotopic Constraints on the Provenance of Antarctic Dust and Atmospheric Circulation Patterns Prior to the Mid-Brunhes Event (~430 kyr ago)

Han, Changhee., Burn, Laurie J., Vallelonga, Paul., **Hur, DoSoon.**, Boutron, Claude F., **Han, Yeongcheol.**, **Lee, Sanghee.** and 2 others.

Molecules. 2022. 27(13).

doi: 10.3390/molecules27134208

A lead (Pb) isotopic record, covering the two oldest glacial-interglacial cycles (~572 to 801 kyr ago) characterized by lukewarm interglacials in the European Project for Ice Coring in Antarctica Dome C ice core, provides evidence for dust provenance in central East Antarctic ice prior to the Mid-Brunhes Event (MBE), ~430 kyr ago. Combined with published post-MBE data, distinct isotopic compositions, coupled with isotope mixing model results, suggest Patagonia/Tierra del Fuego (TdF) as the most important sources of dust during both pre-MBE and post-MBE cold and intermediate glacial periods.

During interglacials, central-western Argentina emerges as a major contributor, resulting from reduced dust supply from Patagonia/TdF after the MBE, contrasting to the persistent dominance of dust from Patagonia/TdF before the MBE. The data also show a small fraction of volcanic Pb transferred from extra-Antarctic volcanoes during post-MBE interglacials, as opposed to abundant transfer prior to the MBE. These differences are most likely attributed to the enhanced wet removal efficiency with the hydrological cycle intensified over the Southern Ocean, associated with a poleward shift of the southern westerly winds (SWW) during warmer post-MBE interglacials, and vice versa during cooler pre-MBE ones. Our results highlight sensitive responses of the SWW and the associated atmospheric conditions to stepwise Antarctic warming.

keywords: lead isotopes; EPICA Dome C ice core; Mid-Brunhes Event; dust and volcanic sources; isotope mixing model; southern westerly winds

1-31 *Meteorology & Atmospheric Sciences*

Local meridional circulation changes contribute to a projected slowdown of the Indian Ocean Walker circulation

Sharma, Sahil., Ha, Kyung-Ja., Cai, Wenju., **Chung, Eui-Seok.** and Bodai, Tamas.

Npj Climate and Atmospheric Science. 2022. 5(1).

doi: 10.1038/s41612-022-00242-w

The weakening of zonal atmospheric circulation, a widely accepted projection of climate change in response to global warming, features a weakening of the Indian Ocean Walker circulation (IWC), with an anomalous ascending motion over the western and anomalous descending motion over the eastern Indian Ocean. The projected IWC weakening has previously been attributed to slower warming in the east than the west, that is, to a positive Indian Ocean Dipole (IOD)-like warming pattern. However, such a warming pattern can also be induced by IWC weakening. As a result, the cause-and-effect relationship cannot be easily determined, and the projected change is poorly constrained and highly uncertain. Here, using a suite of coupled climate model simulations under a high-emission scenario, we find that the IWC slowdown is accompanied by not only a positive IOD-like warming pattern but also anomalous

meridional circulation that is associated with anomalous descending motion over the eastern Indian Ocean. We further show that the anomalous local meridional circulation is closely linked to enhanced land-sea thermal contrast and is unlikely to result from the positive IOD-like warming pattern, suggesting that the IWC weakening is in part driven by the anomalous local meridional circulation. Our findings underscore the important role of local meridional circulation changes in modulating future IWC changes.

1-32 *Astronomy & Astrophysics*

Mesosphere and Lower Thermosphere Winds and Tidal Variations During the 2019 Antarctic Sudden Stratospheric Warming

Liu, Guiping., Janches, Diego., Ma, Jun., Lieberman, Ruth S., Stober, Gunter., Moffat-Griffin, Tracy., Mitchell, Nicholas J., **Kim, Jeong-Han., Lee, Changsup.** and Murphy, Damian J.
Journal of Geophysical Research-Space Physics. 2022.
 127(3).
 doi: 10.1029/2021ja030177

Realistic modeling of the winds and dynamical variations in the mesosphere and lower thermosphere (MLT) at Southern Hemisphere (SH) mid-to-high latitudes near 60°S where dramatic motions occur has been a challenge. This work presents an evaluation of the MLT zonal and meridional winds from ~80 to 98 km altitude produced by the high-altitude version of the Navy Global Environmental Model (NAVGEH-HA) numerical weather prediction system during the Antarctic Sudden Stratospheric Warming (SSW) in September 2019. These results are compared with the coincident measurements by five meteor radars at Tierra del Fuego (TDF; 53.7°S, 67.7°W), King Edward Point (KEP; 54.3°S, 36.5°W), King Sejong Station (KSS; 62.2°S, 58.8°W), Rothera (ROT; 67.5°S, 68.0°W), and Davis (DAV; 68.6°S, 78.0°E) across SH mid-to-high latitudes. We find that the day-to-day variations in NAVGEH-HA winds related to tidal motions are overall consistent with variations in the radar winds, and the daily mean winds have a correlation of 0.7–0.9 between them. Three-hourly NAVGEH-HA winds have a correlation of ~0.5 and mean difference <10 m/s to the radar observations at most stations, and the Root Mean Square (RMS) error ranges from ~25 to 35 m/s. Above 90 km altitude, the correlation coefficient decreases, and the difference and RMS error increase,

indicating an upper limit to the validity of the NAVGEH-HA results. Both the analyzed and observed winds reveal an enhancement in diurnal and semidiurnal tidal amplitude during this SH SSW. NAVGEH-HA shows some evidence that nonmigrating tidal enhancements are produced through the interaction of migrating tides with planetary waves.

keywords: mesosphere and lower thermosphere; tides; meteor radar winds; high altitude data assimilation system; Antarctic stratospheric warming; upper atmosphere; Earth Science

1-33 *Astronomy & Astrophysics*

A Modeling Analysis of the Apparent Linear Relation Between Mesospheric Temperatures and Meteor Height Distributions Measured by a Meteor Radar

Lee, Wonseok., **Lee, Changsup., Kim, Jeong-Han.** and 2 others.
Journal of Geophysical Research-Space Physics. 2022.
 127(1).
 doi: 10.1029/2021ja029812

A new method of estimating mesospheric temperature has recently been proposed by utilizing an apparent linear relation between atmospheric temperatures and full widths at half maximum (FWHMs) of meteor height distributions measured by a meteor radar (MR). However, the new method assumes that the meteor height distribution is dominantly dependent on the atmospheric conditions, rather than on meteoroid characteristics (mass and velocity). In order to verify this assumption, we have developed a meteor ablation model and applied it to the observed parameters by a MR at King Sejong Station (62.2°S, 58.8°W). The simulation results show that the FWHM of meteor height distribution increases linearly with the mesospheric temperature and its linear relation matches well with the observed relation. We found that the seasonal variation of meteor velocity distributions is significant but has only little effect on the variation of the height distribution. We also found that the observed characteristics of meteors are consistent with a Gaussian distribution of logarithmic masses, and this distribution is nearly invariable throughout the year with the average peak value of $10^{-6.2}$ kg. Thus, we conclude that observed meteor height distributions are mainly dependent on the

mesospheric temperature, and can be used as a mesospheric temperature indicator.

keywords: meteor; mesosphere; meteor radar (MR); meteor ablation

1-34 *Environmental Sciences & Ecology; Geology; Remote Sensing; Imaging Science & Photographic Technology*

Monitoring Asbestos Mine Remediation Using Airborne Hyperspectral Imaging System: A Case Study of Jefferson Lake Mine, US

Jeong, Yongsik, Yu, Jaehyung., Wang, Lei., Huy Hoa, Huynh. and **Kim, Hyun-Cheol**.

Remote Sensing. 2022. 14(21).

doi: 10.3390/rs14215572

This study investigated an asbestos mine restoration project using Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) hyperspectral data. The distribution of an abandoned asbestos mine (AAM) and treatment area were analyzed before and after the remediation based on the spectral indices for detecting naturally occurring asbestos (NOA) indicators and encapsulation. The spectral indices were developed for NOA, host rock, and encapsulation by logistic regression models using spectral bands extracted from the random forest algorithm. The detection models mostly used VNIR spectra rather than SWIR and were statistically significant. The overall accuracy of the detection models was approximately 84%. Notably, the detection accuracy of non-treated and treated areas was increased to about 96%, excluding the host rock index. The NOA index detected asbestos in the mine area as well as those in outcrops outside of the mine. It has been confirmed that the NOA index can be efficiently applied to all cases of asbestos occurrence. The remote sensing data revealed that the mine area was increased by similar to 5% by the remediation, and the treatment activity reduced asbestos exposure by similar to 32%. Moreover, the integrative visualization between the detection results and 3D high-resolution images provided an intuitive and realistic understanding of the reclamation project.

keywords: naturally occurring asbestos (NOA); abandoned asbestos mine; mine remediation; AVIRIS hyperspectral data; binary logistic regression; image classification; spectroscopy

1-35 *Environmental Sciences & Ecology; Remote Sensing; Imaging Science & Photographic Technology*

Monitoring permafrost changes in central Yakutia using optical and polarimetric SAR data

Park, Sang-Eun., Jung, Yoon Taek. and **Kim, Hyun-Cheol**.

Remote Sensing of Environment. 2022. 274.

doi: 10.1016/j.rse.2022.112989

The changes in the permafrost environment have been of interest as a sensitive indicator of changes in global climate conditions. Since changes in the soil and ecosystem of the permafrost active layer are spatially and temporally complex depending on many environmental factors, it is not easy to grasp climate-induced changes occurring in coupled atmospheric-ecological-geocryological systems. To understand the changes in the permafrost active layer, spatially detailed monitoring methods such as multi-spectral optical and Synthetic Aperture Radar (SAR) remote sensing technologies have been extensively applied to the permafrost observation. Optical and SAR systems observe different permafrost features due to significant differences in electromagnetic wave frequencies and imaging mechanisms. Therefore, most studies used optical and SAR data separately according to the purpose and characteristics of each study. The objective of this study is to explore the possibility of combined interpretation of optical and SAR data for identifying and understanding spatiotemporal details of the short- and long-term changes occurring in the permafrost active layer. Multi-spectral optical images acquired during the thawing period and L-band polarimetric SAR images acquired during the freezing period are used in this study in order to examine ecological characteristics and cryogenic processes, respectively. The result of analyzing the relationship between information obtained from optical and SAR sensors revealed that there was a significant correlation between winter changes in scattering properties observed in SAR data and summer land cover changes observed in optical data. The scattering characteristics of winter soil were found to be particularly related to the ecosystem changes in areas that can be explained by the thermokarst development process. Additional data from independent sources, such as elevation data, meteorological data, and long-term optical data, consistently supported the relationship between the winter SAR observations and the thermokarst-related

ecosystem changes. The experimental results also elucidated that polarimetric scattering mechanism indicators representing the signal depolarization and surface roughness properties played an important role in deriving information related to the permafrost process from the winter SAR data.

keywords: Permafrost; Thermokarst; Landsat; Synthetic Aperture Radar; ALOS PALSAR; Polarimetric SAR

1-36 *Meteorology & Atmospheric Sciences*

The Ny-Ålesund Aerosol Cloud Experiment (NASCENT): Overview and First Results

Pasquier, J. T., David, R. O., Freitas, G., Gierens, R., Gramlich, Y., Haslett, S., Li, G., Schaefer, B., Siegel, K., Wieder, J., Adachi, K., Belosi, F., Carlsen, T., Decesari, S., Ebell, K., Gilardoni, S., Gysel-Beer, M., Henneberger, J., Inoue, J., Kanji, Z. A., Koike, M., Kondo, Y., Krejci, R., Lohmann, U., Maturilli, M., Mazzolla, M., Modini, R., Mohr, C., Motos, G., Nenes, A., Nicosia, A., Ohata, S., Paglione, M., **Park, Sang-Jong**, and 10 others.

Bulletin of the American Meteorological Society. 2022. 103(11): E2533-E2558.

doi: 10.1175/bams-d-21-0034.1

The Arctic is warming at more than twice the rate of the global average. This warming is influenced by clouds, which modulate the solar and terrestrial radiative fluxes and, thus, determine the surface energy budget. However, the interactions among clouds, aerosols, and radiative fluxes in the Arctic are still poorly understood. To address these uncertainties, the Ny-Ålesund Aerosol Cloud Experiment (NASCENT) study was conducted from September 2019 to August 2020 in Ny-Ålesund, Svalbard. The campaign's primary goal was to elucidate the life cycle of aerosols in the Arctic and to determine how they modulate cloud properties throughout the year. In situ and remote sensing observations were taken on the ground at sea level, at a mountaintop station, and with a tethered balloon system. An overview of the meteorological and the main aerosol seasonality encountered during the NASCENT year is introduced, followed by a presentation of first scientific highlights. In particular, we present new findings on aerosol physicochemical and molecular properties. Further, the role of cloud droplet activation and ice crystal nucleation in the formation and persistence of mixed-phase clouds, and the occurrence of secondary ice processes, are

discussed and compared to the representation of cloud processes within the regional Weather Research and Forecasting Model. The paper concludes with research questions that are to be addressed in upcoming NASCENT publications.

keywords: Atmosphere; Arctic; Cloud microphysics; Cloud radiative effects; Aerosols; Aerosol-cloud interaction

1-37 *Environmental Sciences & Ecology; Geology; Meteorology & Atmospheric Sciences*

Observations of submesoscale eddy-driven heat transport at an ice shelf calving front

Friedrichs, Drew M., McInerney, Jasmin B. T., Oldroyd, Holly J., **Lee, Won Sang**, **Yun, Sukyoung**, and 7 others.

Communications Earth & Environment. 2022. 3(1).

doi: 10.1038/s43247-022-00460-3

Antarctica's ice shelves buttress the continent's terrestrial ice, helping slow the loss of grounded ice into the ocean and limiting sea level rise. Ice-ocean interaction plays a critical role in ice shelf stability by driving basal melt rates. Consequently, improved prediction of the future state of ice shelves lies in understanding the coastal ocean mechanics that deliver heat to their cavities. Here, we present autonomous glider-based observations of a coherent structure at the calving front of a cold-water cavity ice shelf (Nansen Ice Shelf, East Antarctica). This ~10 km-wide eddy dominated the local ocean circulation in the austral summer of 2018/2019, promoting an upwelling of cold ice shelf water and a deepening of warm surface water. Microstructure turbulence measurements show a resulting maximum vertical heat transport of 10 W m^{-2} at depths equivalent to the ice shelf draft. Similar eddy-driven heat transport further into the ice shelf cavity would support enhanced summertime melt in regions of shallower ice draft.

1-38 *Science & Technology*

Performance Assessment of Two-stream Convolutional Long- and Short-term Memory Model for September Arctic Sea Ice Prediction from 2001 to 2021

Chi, Junhwa.

Korean Journal of Remote Sensing. 2022. 38(6): 1047-1056.

doi: 10.7780/kjrs.2022.38.6.1.6

Sea ice, frozen sea water, in the Arctic is a primary indicator of global warming. Due to its importance to the climate system, shipping-route navigation, and fisheries, Arctic sea ice prediction has gained increased attention in various disciplines. Recent advances in artificial intelligence (AI), motivated by a desire to develop more autonomous and efficient future predictions, have led to the development of new sea ice prediction models as alternatives to conventional numerical and statistical prediction models. This study aims to evaluate the performance of the two-stream convolutional long and short-term memory (TS-ConvLSTM) AI model, which is designed for learning both global and local characteristics of the Arctic sea ice changes, for the minimum September Arctic sea ice from 2001 to 2021, and to show the possibility for an operational prediction system. Although the TSConvLSTM model generally increased the prediction performance as training data increased, predictability for the marginal ice zone, 5-50% concentration, showed a negative trend due to increasing first-year sea ice and warming. Additionally, a comparison of sea ice extent predicted by the TS-ConvLSTM with the median Sea Ice Outlooks (SIOs) submitted to the Sea Ice Prediction Network has been carried out. Unlike the TS-ConvLSTM, the median SIOs did not show notable improvements as time passed (i.e., the amount of training data increased). Although the TSConvLSTM model has shown the potential for the operational sea ice prediction system, learning more spatio-temporal patterns in the difficult-to-predict natural environment for the robust prediction system should be considered in future work.

keywords: Arctic; Artificial intelligence; CNN; ConvLSTM; LSTM; Prediction; Sea ice

hyperspectral sensor, and a lidar sensor. As a result of the physical offset, a misalignment between each image can be occurred along with a flight direction. In particular, in a case of multisensor system, an observation sensor has to be replaced regularly to equip another observation sensor, and then, a high cost should be paid to acquire a calibration parameter. In this study, we establish a precise sensor model equation to apply for a multiple sensor in common and propose an independent physical offset estimation method. The proposed method consists of 3 steps. Firstly, we define an appropriate rotation matrix for our system, and an initial sensor model equation for direct georeferencing. Next, an observation equation for the physical offset estimation is established by extracting a corresponding point between a ground control point and the observed data from a sensor. Finally, the physical offset is estimated based on the observed data, and the precise sensor model equation is established by applying the estimated parameters to the initial sensor model equation. 4 region's datasets (Jeon-ju, Incheon, Alaska, Norway) with a different latitude, longitude were compared to analyze the effects of the calibration parameter. We confirmed that a misalignment between images were adjusted after applying for the physical offset in the sensor model equation. An absolute position accuracy was analyzed in the Incheon dataset, compared to a ground control point. For the hyperspectral image, root mean square error (RMSE) for X, Y direction was calculated for 0.12 m, and for the point cloud, RMSE was calculated for 0.03 m. Furthermore, a relative position accuracy for a specific point between the adjusted point cloud and the hyperspectral images were also analyzed for 0.07 m, so we confirmed that a precise data mapping is available for an observation without a ground control point through the proposed estimation method, and we also confirmed a possibility of multi-sensor fusion. From this study, we expect that a flexible multi-sensor platform system can be operated through the independent parameter estimation method with an economic cost saving.

keywords: Physical offset; Multi-sensor fusion; Hyperspectral sensor; LiDAR sensor

1-39 Science & Technology

Physical Offset of UAVs Calibration Method for Multi-sensor Fusion

Kim, Cheolwook., Lim, Pyeong-chae., **Chi, Junhwa.** and 2 others.

Korean Journal of Remote Sensing. 2022. 38(6): 1125-1139.

doi: 10.7780/kjrs.2022.38.6.1.13

In an unmanned aerial vehicles (UAVs) system, a physical offset can be existed between the global positioning system/inertial measurement unit (GPS/IMU) sensor and the observation sensor such as a

Predictability of the winter haze pollution in Beijing-Tianjin-Hebei region in the context of stringent emission control

Zhang, Ziyin., Zhao, Xiujuan., Mao, Rui., Xu, Jing. and **Kim, Seong-Joong.**

Atmospheric Pollution Research. 2022. 13(5).

doi: 10.1016/j.apr.2022.101392

Previous studies have demonstrated that seasonal weather forecasting together with the functional relationship between atmospheric circulation indices and the pollution level can facilitate the prediction of haze/air quality in the heavily polluted Beijing-Tianjin-Hebei region (BTH). Air quality is sensitive to pollution emissions, which have been significantly curtailed since 2012 across most of China. This raises the question of the predictability of winter haze pollution in BTH in the context of greatly emission controls. Thus the stability of the relationship between atmospheric circulation and haze pollution in BTH was examined in the study. The results suggest that the winter haze pollution in Beijing and BTH can still be highly predicted by using the atmospheric circulations, despite significant reductions in pollutant emissions and fundamental improvements in air quality in recent years. The high predictability may be attributed mainly to two reasons, namely the physical mechanism of the influence of atmospheric circulation on winter meteorological conditions region and the high amount and intensity of pollutants emission in BTH. The numerical simulations reveal that the probability of air pollution (PAP) may decrease nonlinearly and vary among regions. As the base emissions in 2016 decreased to 50% at a rate of 10%, the PAP moderately decreased from 77.2% to 57.6% in the heavily polluted BTH. It is likely that winter haze events may still occur frequently in BTH when suffering adverse meteorological conditions in the near future. Therefore, a further understanding of the predictability is conducive to prediction and management of air pollution.

keywords: Air pollution/haze; Atmospheric circulation; Predictability; Emission control; Beijing-Tianjin-Hebei

Review of Environmental Monitoring by Means of Radio Waves in the Polar Regions: From Atmosphere to Geospace

Alfonsi, Lucilla., Bergeot, Nicolas., Cilliers, Pierre J., De Franceschi, Giorgia., Baddeley, Lisa., Correia, Emilia., Di Mauro, Domenico., Enell, Carl-Fredrik., Engebretson, Mark., Ghoddousi-Fard, Reza., Haggstrom, Ingemar., **Ham, Young-bae.**, Heygster, Georg., **Jee, Geonhwa.**, Kero, Antti., Kosch, Michael., **Kwon, Hyuck-Jin.**, **Lee, Changsup.** and 20 others.

Surveys in Geophysics. 2022. 43(6): 1609-1698.

doi: 10.1007/s10712-022-09734-z

The Antarctic and Arctic regions are Earth's open windows to outer space. They provide unique opportunities for investigating the troposphere-thermosphere-ionosphere-plasmasphere system at high latitudes, which is not as well understood as the mid- and low-latitude regions mainly due to the paucity of experimental observations. In addition, different neutral and ionised atmospheric layers at high latitudes are much more variable compared to lower latitudes, and their variability is due to mechanisms not yet fully understood. Fortunately, in this new millennium the observing infrastructure in Antarctica and the Arctic has been growing, thus providing scientists with new opportunities to advance our knowledge on the polar atmosphere and geospace. This review shows that it is of paramount importance to perform integrated, multi-disciplinary research, making use of long-term multi-instrument observations combined with ad hoc measurement campaigns to improve our capability of investigating atmospheric dynamics in the polar regions from the troposphere up to the plasmasphere, as well as the coupling between atmospheric layers. Starting from the state of the art of understanding the polar atmosphere, our survey outlines the roadmap for enhancing scientific investigation of its physical mechanisms and dynamics through the full exploitation of the available infrastructures for radio-based environmental monitoring.

keywords: Antarctica; Arctic; Ionosphere; Multi-instrument monitoring; Radio-based monitoring

1-42 WOSCategory

Seasonal Dependence of Aerosol Data Assimilation and Forecasting Using Satellite and Ground-Based Observations

Lee, Seunghee., Kim, Ganghan., Lee, Myong-In., **Choi, Yonghan.** and 2 others.

Remote Sensing. 2022. 14(9).

doi: 10.3390/rs14092123

This study examines the performance of a data assimilation and forecasting system that simultaneously assimilates satellite aerosol optical depth (AOD) and ground-based PM₁₀ and PM_{2.5} observations into the Weather Research and Forecasting model coupled with Chemistry (WRF-Chem). The data assimilation case for the surface PM₁₀ and PM_{2.5} concentrations exhibits a higher consistency with the observed data by showing more correlation coefficients than the no-assimilation case. The data assimilation also shows beneficial impacts on the PM₁₀ and PM_{2.5} forecasts for South Korea for up to 24 h from the updated initial condition. This study also finds deficiencies in data assimilation and forecasts, as the model shows a pronounced seasonal dependence of forecasting accuracy, on which the seasonal changes in regional atmospheric circulation patterns have a significant impact. In spring, the forecast accuracy decreases due to large uncertainties in natural dust transport from the continent by north-westerlies, while the model performs reasonably well in terms of anthropogenic emission and transport in winter. When the south-westerlies prevail in summer, the forecast accuracy increases with the overall reduction in ambient concentration. The forecasts also show significant accuracy degradation as the lead time increases because of systematic model biases. A simple statistical correction that adjusts the mean and variance of the forecast outputs to resemble those in the observed distribution can maintain the forecast skill at a practically useful level for lead times of more than a day. For a categorical forecast, the skill score of the data assimilation run increased by up to 37% compared to that of the case with no assimilation, and the skill score was further improved by 10% through bias correction.

keywords: data assimilation; air quality modeling; aerosol forecast; seasonal dependence

1-43 Environmental Sciences & Ecology;

Public, Environmental & Occupational Health

Seasonality of Radon-222 near the surface at King Sejong Station (62°S), Antarctic Peninsula, and the role of atmospheric circulation based on observations and CAM-Chem model

Jun, Sang-Yoon., Choi, Jung., Chambers, S. D., **Oh, Mingi.**, **Park, Sang Jong.**, **Choi, Taejin.**, **Kim, Seong-Joong.**, Williams, A. G. and **Hong, Sang Bum.**

Environmental Research. 2022. 214.

doi: 10.1016/j.envres.2022.113998

We examined the seasonal cycle of radon concentration observed at King Sejong Station (KSG, 62°S), Antarctic Peninsula, during the period 2013–2016. The distribution of monthly radon concentration was found to be highly positively skewed from March through October (austral autumn to spring) due to large numbers of short-lived periods of high radon concentration. The global atmospheric chemistry model (CAM-Chem), which includes all global terrestrial sources of radon except for those in Antarctica, well reproduces the observed seasonal cycle of monthly-mean radon concentration at KSG. Further offline experiments suggest that uncertainties in radon emissions over South America and the Southern Ocean should be improved for the simulations of radon in Antarctica. The results demonstrate that seasonally varying transport of radon in the boundary layer from South America substantially affects the seasonality of monthly mean radon concentration at KSG. The composite analyses further reveal that high radon events at KSG are the result of a distinct east-west dipole-like structure associated with surface cyclonic circulation over the Bellingshausen Sea and anticyclonic circulation in the Weddell Sea. This atmospheric pattern provides favorable conditions for radon transport into KSG from the northwest. The relationship between radon concentration at KSG and climate variability is also discussed in this study.

keywords: Antarctica; CAM-Chem; King sejong station; Radon; Seasonality.

Significant relationship between Arctic warming and East Asia hot summers

Kim, Da-Seul., **Jun, Sang-Yoon.** and 2 others.

International Journal of Climatology. 2022. 42(16): 9530-9538.

doi: 10.1002/joc.7844

Arctic warming is of growing interest because it could affect midlatitude climates. Even though numerous studies have paid attention to the relationship between Arctic warming and the midlatitude climate in winter, the influence of Arctic warming on the summer conditions has not been examined in depth. Here we identify a significant relationship between East Asia hot summers and Arctic warming over the Barents and Kara seas. To represent Arctic warming, we define a combined index by simply differencing the normalized surface air temperature and sea-ice indices. We found that the combined index in July has significantly high correlations with the temperatures in China, Korea, and Japan. While the teleconnection mechanism is not completely revealed, it is evident that warming over the Barents and Kara seas is accompanied by the local development of an anomalous anticyclone and downstream wave trains, which yield a strong anticyclonic circulation over East Asia and the North Pacific. The anticyclonic circulation persists and intensifies until August, which leads to hot summer conditions in East Asia with warm advection and enhanced shortwave radiation. Our results suggest that Arctic climate conditions can be used as a useful precursor of East Asia temperature variations even in summer.

keywords: Arctic Warming; East Asia; teleconnection

Societal implications of a changing Arctic Ocean

Huntington, Henry P., Zagorsky, Andrey., Kaltenborn, Bjorn P., **Shin, Hyoung Chul.** and 5 others.

Ambio. 2022. 51(2): 298-306.

doi: 10.1007/s13280-021-01601-2

The Arctic Ocean is undergoing rapid change: sea ice is being lost, waters are warming, coastlines are eroding,

species are moving into new areas, and more. This paper explores the many ways that a changing Arctic Ocean affects societies in the Arctic and around the world. In the Arctic, Indigenous Peoples are again seeing their food security threatened and cultural continuity in danger of disruption. Resource development is increasing as is interest in tourism and possibilities for trans-Arctic maritime trade, creating new opportunities and also new stresses. Beyond the Arctic, changes in sea ice affect mid-latitude weather, and Arctic economic opportunities may re-shape commodities and transportation markets. Rising interest in the Arctic is also raising geopolitical tensions about the region. What happens next depends in large part on the choices made within and beyond the Arctic concerning global climate change and industrial policies and Arctic ecosystems and cultures.

keywords: Arctic Ocean; Climate change; Ecology; Geopolitics; Indigenous Peoples; Sea ice.

Spacecraft Potential Changes Associated With EMIC Waves in the Inner Magnetosphere

Kim, Khan-Hyuk., Lee, Junhyun., Kwon, Jong-Woo., Lee, Ensang., Kim, Hee-Eun., Jin, Ho., **Kwon, Hyuck-Jin.** and 3 others.

Journal of Geophysical Research-Space Physics. 2022. 127(9).

doi: 10.1029/2022ja030337

Although electromagnetic ion cyclotron (EMIC) waves are commonly observed in the magnetosphere and are believed to energize background cold ions, it is not clear whether EMIC waves play a significant role in determining spacecraft potential change. In this paper, we present two strong He-band EMIC wave events observed by the Van Allen Probe-B spacecraft inside the plasmasphere. One event occurred on 11 March 2016 when the spacecraft was on the dayside, and the other occurred on 9 October 2016 when the spacecraft was in the postmidnight sector. When a strong He-band EMIC wave activity was detected, low-energy ion flux enhancements occurred nearly simultaneously with the EMIC wave power enhancements. Both events presented in this study are clearly unique in that He-band wave power and enhanced proton flux are extremely high. During the wave activity interval, we found that the spacecraft charged more positively

without a significant change in the ambient electron density. We discuss whether low-energy ions energized by EMIC waves can contribute to the spacecraft potential change.

1-47 *Astronomy & Astrophysics; Physics*

TAROG-M: radio antenna array on antarctic high mountain for detecting near-horizontal ultra-high energy air showers

Wang, Shih-Hao., Nam, Jiwoo., Chen, Pisin., Chen, Yaocheng., **Choi, Taejin., Ham, Young-bae.,** Hsu, Shih-Ying., Huang, Jian-Jung., Huang, Ming-Huey A., **Jee, Geonhwa.,** Jung, Jongil., **Kim, Jieun.,** Kuo, Chung-Yun., **Kwon, Hyuck-Jin., Lee, Changsup.** and 30 others.

Journal of Cosmology and Astroparticle Physics. 2022.(11).

doi: 10.1088/1475-7516/2022/11/022

The TAROG-M radio observatory is a self-triggered antenna array on top of the ~2700 m high Mt. Melbourne in Antarctica, designed to detect impulsive geomagnetic emission from extensive air showers induced by ultra-high energy (UHE) particles beyond 10^{17} eV, including cosmic rays, Earth-skimming tau neutrinos, and particularly, the "ANITA anomalous events" (AAE) from near and below the horizon. The six AAE discovered by the ANITA experiment have signal features similar to tau neutrinos but that hypothesis is in tension either with the interaction length predicted by Standard Model or with the flux limits set by other experiments. Their origin remains uncertain, requiring more experimental inputs for clarification. The detection concept of TAROG-M takes advantage of a high altitude with synoptic view toward the horizon as an efficient signal collector, and the radio quietness as well as strong and near vertical geomagnetic field in Antarctica, enhancing the relative radio signal strength. This approach has a low energy threshold, high duty cycle, and is easy to extend for quickly enlarging statistics. Here we report experimental results from the first TAROG-M station deployed in January 2020, corresponding to approximately one month of livetime. The station consists of six receiving antennas operating at 180–450 MHz, and can reconstruct source directions of impulsive events with an angular resolution of $\sim 0.3^\circ$, calibrated *in situ* with a drone-borne pulser system. To demonstrate TAROG-M's ability to detect UHE air showers, a search for cosmic ray signals in 25.3-days of data together

with the detection simulation were conducted, resulting in seven identified candidates. The detected events have a mean reconstructed energy of $0.95_{-0.31}^{+0.46}$ EeV and zenith angles ranging from 25° to 82° , with both distributions agreeing with the simulations, indicating an energy threshold at about 0.3 EeV. The estimated cosmic ray flux at that energy is $1.2_{-0.9}^{+0.7} \times 10^{-16} \text{ eV}^{-1} \text{ km}^{-2} \text{ yr}^{-1} \text{ sr}^{-1}$, also consistent with results of other experiments. The TAROG-M sensitivity to AAEs is approximated by the tau neutrino exposure with simulations, which suggests comparable sensitivity as ANITA's at around 1 EeV energy with a few station-years of operation. These first results verified the station design and performance in a polar and high-altitude environment, and are promising for further discovery of tau neutrinos and AAEs after an extension in the near future.

keywords: ultra high energy neutrinos; neutrino experiments; ultra high energy cosmic rays; cosmic ray experiments

1-48 *Geology*

Under-Ice Light Field in the Western Arctic Ocean During Late Summer

Veyssiere, Gaele., Castellani, Giulia., Wilkinson, Jeremy., Karcher, Michael., Hayward, Alexander., Stroeve, Julianne C., Nicolaus, Marcel., **Kim, Joo-Hong., Yang, Eun-Jin.,** Valcic, Lovro., Kauker, Frank., Khan, Alia L., Rogers, Indea. and **Jung, Jinyoung.**

Frontiers in Earth Science. 2022. 9.

doi: 10.3389/feart.2021.643737

The Arctic is no longer a region dominated by thick multi-year ice (MYI), but by thinner, more dynamic, first-year-ice (FYI). This shift towards a seasonal ice cover has consequences for the under-ice light field, as sea-ice and its snow cover are a major factor influencing radiative transfer and thus, biological activity within- and under the ice. This work describes *in situ* measurements of light transmission through different types of sea-ice (MYI and FYI) performed during two expeditions to the Chukchi sea in August 2018 and 2019, as well as a simple characterisation of the biological state of the ice microbial system. Our analysis shows that, in late summer, two different states of FYI exist in this region: 1) FYI in an enhanced state of decay, and 2) robust FYI, more likely to survive the melt season. The two FYI types have different average ice thicknesses: 0.74 ± 0.07 m (N = 9) and 0.93

± 0.11 m ($N = 9$), different average values of transmittance: 0.15 ± 0.04 compared to 0.09 ± 0.02 , and different ice extinction coefficients: 1.49 ± 0.28 and 1.12 ± 0.19 m⁻¹. The measurements performed over MYI present different characteristics with a higher average ice thickness of 1.56 ± 0.12 m, lower transmittance (0.05 ± 0.01) with ice extinction coefficients of 1.24 ± 0.26 m⁻¹ ($N = 12$). All ice types show consistently low salinity, chlorophyll *a* concentrations and nutrients, which may be linked to the timing of the measurements and the flushing of melt-water through the ice. With continued Arctic warming, the summer ice will continue to retreat, and the decayed variant of FYI, with a higher scattering of light, but a reduced thickness, leading to an overall higher light transmittance, may become a more relevant ice type. Our results suggest that in this scenario, more light would reach the ice interior and the upper-ocean.

keywords: Arctic; First-year ice; Ice extinction coefficient; Late summer; Transmittance; Under-ice irradiance

1-49 *Environmental Sciences & Ecology;*
Public, Environmental & Occupational Health

Validations of satellite ozone profiles in austral spring using ozonesonde measurements in the Jang Bogo station, Antarctica

Lee, Hana., **Choi, Taejin., Kim, Seong-Joong.** and 6 others.
Environmental Research. 2022. 214.
doi: 10.1016/j.envres.2022.114087

Using ozonesonde measurements from 2015 to 2018 at the Jang Bogo station located in the southeastern Antarctic region, we evaluate ozone profiles retrieved from the three satellite measurements that are widely used: Ozone Monitoring Instrument (OMI), Microwave Limb Sounder (MLS), and Ozone Mapping Profiler Suite (OMPS) data. For the fair validation, ozonesonde profiles are smoothed using the weighting function of each satellite retrieval algorithm (i.e., convolution process). Compared with limb-viewing MLS and OMPS ozone profiles, the OMI ozone profiles are relatively less qualified: coarser vertical resolution and larger inter-annual variation. Nevertheless, our validation reveals that the quality of all three satellite ozone profiles looks comparable; In general, difference from ozonesonde profile is ~ 1 ppm absolutely, and -20 to

30% relatively at maximum. This quantitative range well corresponds to previous work, meaning that our new validation confirms the reliability of satellite ozone profiles in the southeastern Antarctic region where the measurement data for the validation were not enough. Another interesting feature is the role of a priori ozone profile; Nadir-viewing OMI satellite can have qualified ozone profiles by a proper assumption of a priori ozone profile. Since the performance of limb-viewing ozone profiles is better, however, the careful usage of nadir-viewing ozone profile is still required. We think that the simultaneous usage of multiple satellite ozone profiles can contribute to better understanding of Antarctic ozone characteristics.

keywords: Jang Bogo station; MLS; OMI; OMPS; Ozone profile; Ozonesonde.

1-50 *Environmental Sciences & Ecology*

Variations in lead isotopes in Antarctic snow from northern Victoria Land during 2012-2015

Han, Changhee., Kim, Songyi., Lee, Ah-Hyung., Han, Yeongcheol., Lee, Seungmi., Chang, Chaewon., Hong, Sungmin, **Jung, Hyejin., Hong, Sang-Bum.,** Lee, Jeonghoon. and **Hur, Soon Do.**

Environmental Research Communications. 2022. 4(5).
doi: 10.1088/2515-7620/ac6cd1

To evaluate recent changes in anthropogenic Pb pollution and its sources and origins in Antarctica, Pb and Ba concentrations and Pb isotopic compositions were determined in a continuous series of 40 snow samples from a 2-m deep snow pit, covering 4 full years from 2011/12 summer to 2015/16 summer, at the Hercules Neve plateau in Victoria Land, Antarctica. The results show that more than 90% of the atmospheric Pb deposited in Victoria Land was of noncrustal origin. This result implies the persistence of a significant human impact on the atmospheric cycle of Pb in the most remote places on Earth, despite a substantial reduction in anthropogenic Pb emissions in the Southern Hemisphere during recent years. The Pb isotopic fingerprints indicate that South America, particularly Brazil and Chile, has become a major source of anthropogenic Pb reaching Victoria Land. Our data highlight the need for both national and international measures to further reduce Pb emissions. To evaluate recent changes in anthropogenic Pb

pollution and its sources and origins in Antarctica, Pb and Ba concentrations and Pb isotopic compositions were determined in a continuous series of 40 snow samples from a 2-m deep snow pit, covering 4 full years from 2011/12 summer to 2015/16 summer, at the Hercules N  v   plateau in Victoria Land, Antarctica. The results show that more than 90% of the atmospheric Pb deposited in Victoria Land was of noncrustal origin. This result implies the persistence of a significant human impact on the atmospheric cycle of Pb in the most remote places on Earth, despite a substantial reduction in anthropogenic Pb emissions in the Southern Hemisphere during recent years. The Pb isotopic fingerprints indicate that South America, particularly Brazil and Chile, has become a major source of anthropogenic Pb reaching Victoria Land. Our data highlight the need for both national and international measures to further reduce Pb emissions.

keywords: antarctic snow; lead isotopes; northern victoria land; anthropogenic Pb

spectroscopy, fluorescence spectroscopy, and radical quenching experiments. The production of radical species (particularly $\cdot\text{OH}$), which was negligible under dark conditions, is responsible for the enhanced degradation of propranolol in the presence of PMS under visible light. The positive effect of visible light on the propranolol degradation was observed in the PMS concentration range and the pH range of 100–3000 μM and 3–9, respectively. Compared to the visible light/platinum-loaded tungsten oxide (Pt- WO_3) system, the visible light/PMS system showed a superior ability to degrade propranolol (degradation efficiency after 2 h of visible-light irradiation=71.0% in the visible light/PMS system vs. 58.3% in the visible light/Pt- WO_3 system).

keywords: Propranolol; Peroxymonosulfate; Visible-light-active degradation products; Hydroxyl radical; Cost-effective water treatment method

1-51 Engineering

Visible light-induced degradation of propranolol with peroxymonosulfate as an oxidant and a radical precursor

Phan, Hong Thi Bich., Nguyen, Anh Quoc Khuong., **Ahn, Yong-Yoon., Kim, Kitae.** and 2 others.

Separation and Purification Technology. 2022. 289.

doi: 10.1016/j.seppur.2022.120764

A cost-effective method for the degradation of propranolol, which does not require a high amount of energy and expensive materials/chemicals, was developed. The degradation of propranolol by peroxymonosulfate (PMS) was slow under dark conditions. However, visible-light irradiation significantly accelerated the PMS-mediated propranolol degradation (degradation efficiency after 2h=71.0% under visible light vs. 9.7% under dark conditions), although neither PMS nor propranolol absorbed the visible light. The degradation products generated from the oxidation of propranolol by PMS absorb visible light, which facilitates the photochemical reduction of PMS and oxygen and the production of various free radicals, such as superoxide ($\text{O}_2^{\cdot-}$), hydroxyl ($\cdot\text{OH}$), and sulfate radicals ($\text{SO}_4^{\cdot-}$). These behaviors were verified by ultraviolet-visible absorption spectroscopy, electron spin resonance

1-52 Environmental Sciences & Ecology

When river water meets seawater: Insights into primary marine aerosol production

Park, Jiyeon., Jang, Jiye., Yoon, Young Jun., Kang, Sujin, Kang, Hyojin., Park, Kihong, Cho, Kyung Hwa, **Kim, Jung-Hyun.,** Dall'Osto, Manuel. and **Lee, Bang Yong.**

Science of the Total Environment. 2022. 807.

doi: 10.1016/j.scitotenv.2021.150866

The impact of inorganic salts and organic matter (OM) on the production of primary marine aerosols is still under debate. To constrain their impact, we investigated primary aerosols generated by a sea-spray generator chamber using surface water samples from rivers, estuaries, and seas that were collected along salinity gradients in two temperate Korean coastal systems and one Arctic coastal system. Salinity values showed an increasing trend along the river-estuary-coastal water transition, indicating the lowest amount of inorganic salts in the river but the highest amount in the sea. In river samples, the lowest number concentration of primary aerosol particles ($1.01 \times 10^3 \text{ cm}^{-3}$) was observed at the highest OM content, suggesting that low salinity controls aerosol production. Moreover, the number concentration of primary aerosols increased drastically in estuarine ($1.13 \times 10^4 \text{ cm}^{-3}$) and seawater ($1.35 \times 10^4 \text{ cm}^{-3}$) samples as the OM content decreased. Our results indicate that inorganic salts associated with increasing salinity play a much larger role than OM in

aerosol production in river-dominated coastal systems. Laboratory studies using NaCl solution supported the conclusion that inorganic salt is a critical factor in modulating the particles produced from river water and seawater. Accordingly, this study highlights that inorganic salts are a critical factor in modulating the production of primary marine aerosols.

keywords: Primary marine aerosol; Chamber study; Inorganic salts; Organic matter; River-dominated coastal systems

manipulations (average 7.9 days advance and 5.5 days delay, respectively) were substantially lower than the temporal variation over natural spatial gradients within a given year (mean range 56 days) or among years (mean range 32 days). Differences between snow study approaches need to be accounted for when projecting snow dynamics and their impact on ecosystems in future climates.

keywords: review; tundra; ground temperatures; snow experiments; ITEX

1-53 *Environmental Sciences & Ecology; Science & Technology*

Winters are changing: snow effects on Arctic and alpine tundra ecosystems

Rixen, Christian., Høye, Toke Thomas., Macek, Petr., Aerts, Rien., Alatalo, Juha M., Anderson, Jill T., Arnold, Pieter A., Barrio, Isabel C., Bjerke, Jarle W., Björkman, Mats P., Blok, Daan., Blume-Werry, Gesche., Boike, Julia., Bokhorst, Stef., Carbognani, Michele., Christiansen, Casper T., Convey, Peter., Cooper, Elisabeth J., Cornelissen, J. Hans C., Coulson, Stephen J., Dorrepaal, Ellen., Elberling, Bo., Elmendorf, Sarah C., Elphinstone, Cassandra., Forte, T'ai G. W., Frei, Esther R., Geange, Sonya R., Gehrmann, Friederike., Gibson, Casey., Grogan, Paul., Halbritter, Aud Helen., Harte, John., Henry, Gregory H. R., Inouye, David W., Irwin, Rebecca E., Jespersen, Gus., Jonsdóttir, Ingibjörg Svala., **Jung, Ji Young.** and 30 others.

Arctic Science. 2022. 8(3): 572-608.

doi: 10.1139/as-2020-0058

Snow is an important driver of ecosystem processes in cold biomes. Snow accumulation determines ground temperature, light conditions, and moisture availability during winter. It also affects the growing season's start and end, and plant access to moisture and nutrients. Here, we review the current knowledge of the snow cover's role for vegetation, plant- animal interactions, permafrost conditions, microbial processes, and biogeochemical cycling. We also compare studies of natural snow gradients with snow experimental manipulation studies to assess time scale difference of these approaches. The number of tundra snow studies has increased considerably in recent years, yet we still lack a comprehensive overview of how altered snow conditions will affect these ecosystems. Specifically, we found a mismatch in the timing of snowmelt when comparing studies of natural snow gradients with snow manipulations. We found that snowmelt timing achieved by snow addition and snow removal

PART 2

Geo Sciences

2-1 Geochemistry & Geophysics

Antarctic Ice Mass Change (2003-2016) Jointly Estimated by Satellite Gravimetry and Altimetry

Kim, Byeong-Hoon., Seo, Ki-Weon., **Lee, Choon-Ki.** and 3 others.

Journal of Geophysical Research-Solid Earth. 2022. 127(9).
doi: 10.1029/2021jb023297

Accurate estimation of ongoing Antarctic ice mass change is important to predict future ice mass loss and subsequent sea level rise. Over the past two decades, Antarctic ice mass changes have been observed by the gravity recovery and climate experiment (GRACE) gravity mission, but the low spatial resolution of GRACE has limited understanding of glacial-scale contributions. In this study, we combine GRACE and altimetry data to obtain mass change estimates with greatly improved spatial resolution. Combined estimates are obtained by a constrained linear deconvolution algorithm used in a previous GRACE study. Satellite altimetry observations are introduced as an a priori and resulting estimates retain the high spatial resolution of satellite altimetry, but when smoothed agree with low resolution GRACE data. These glacial-scale estimates also agree with ice budget calculations using the input-output method.

sheet, permafrost, and snow) have been speculated to impact (bio)geochemical interactions and element budgets of seawater and pore fluids in Arctic regions. However, this process has rarely been documented in Arctic fjords, which leads to a poor systematic understanding of land-ocean interactions in such a warming-susceptible region. Here, we present the chemical and isotopic ($\delta^{18}\text{O}$, δD , $\delta^{11}\text{B}$, and $^{87}\text{Sr}/^{86}\text{Sr}$) compositions of seawater and pore fluids from five fjords in the Svalbard archipelago. Compared to bottom seawater, the low Cl^- concentrations and depleted water isotopic signatures ($\delta^{18}\text{O}$ and δD) of surface seawater and pore fluids delineate freshwater discharge originating from precipitation and/or meltwater of the cryosphere (i.e., glacier, snow, and permafrost). In contrast, the high Cl^- concentrations with light water isotopic values in pore fluids from Dicksonfjorden indicate a brine probably resulted from submarine permafrost formation during the late Holocene, a timing supported by the numerical simulation of dissolved Cl^- concentration. The freshwater is influenced by the local diagenetic processes such as ion exchanges indicated by $\delta^{11}\text{B}$ signatures as well as interactions with bedrock during fluid migration inferred from pore fluid $^{87}\text{Sr}/^{86}\text{Sr}$ ratios. The interactions with bedrock significantly alter the hydrogeochemical properties of pore fluids in each fjord, yielding spatiotemporal variations. Consequently, land-ocean interactions in combination with the hydrosphere-cryosphere-lithosphere are critical factors for understanding and predicting the hydrology and elemental cycling during global climate change periods in the past, present, and future of the Svalbard archipelago.

keywords: Freshwater discharge; Brine; Water-rock interactions; Svalbard archipelago; Climate change

2-2 Environmental Sciences & Ecology

Assessing the impact of freshwater discharge on the fluid chemistry in the Svalbard fjords

Kim, Ji-Hoon., Ryu, Jong-Sik., Hong, Wei-Li., **Jang, Kwangchul.**, Joo, Young Ji., Lemarchand, Damien., Hur, Jin., Park, Myong-Ho., Chen, Meilian., Kang, Moo-Hee., Park, Sanghee., **Seung-Il, Nam.** and Lee, Yun Kyung.

Science of the Total Environment. 2022. 835.

doi: 10.1016/j.scitotenv.2022.155516

Changes in the cryosphere extent (e.g., glacier, ice

2-3 Physical Geography; Geology; Paleontology

Bioturbation supplying young carbon into West Antarctic continental margin sediment

Kim, Sunghan., McKay, Robert M., **Lee, Jae Il.**, **Yoo, Kyu-Cheul.**, **Lee, Min Kyung.** and **Moon, Heung Soo.**

Palaeogeography Palaeoclimatology Palaeoecology. 2022. 602.

doi: 10.1016/j.palaeo.2022.111161

Accelerator Mass Spectrometry (AMS) ^{14}C dating is a widely applied method for establishing high-precision

chronologies used to underpin late Quaternary paleoclimatic studies. Feedbacks associated with Antarctic Ice Sheets (AIS) and Southern Ocean variance are thought to have played a critical role in regulating past global climate changes since the Last Glacial Maximum. However, determining the exact role of the AIS and Southern Ocean in these changes has proven difficult because of the sparse occurrence of biogenic carbonate suitable for AMS ^{14}C dating in Antarctica. Consequently, AMS ^{14}C dating is often measured on acid insoluble organic matter (AIOM) from bulk sediment samples, which are often biased towards ages that are older than the depositional age, due to pervasive reworking of old carbon. In this scenario, ages can still potentially provide maximum deposition ages, but such interpretations need to be assessed carefully. Here, we document AIOM and foraminifer AMS ^{14}C dates at the same depth intervals from Antarctic continental margin cores, and we find AIOM AMS ^{14}C dates can range between 2000 and 16,000 years younger than those of foraminifera samples. The younger AIOM ^{14}C dates were found in bioturbated sedimentary facies, which often have extremely low sedimentation rates in Antarctica. In cores with low sedimentation rates, the down sediment contribution of organic carbon from macro-benthos can be quite significant in the sediment column with low organic carbon concentration. After considering possibilities of contamination, foraminifer reworking, and remineralization of secondary carbonate to explain this offset, we conclude that bioturbation plays an important role in the Antarctic carbon cycle as a young carbon supplier to depth into the sediment column. This has clear implications for using condensed sedimentary sections to date post-LGM records in Antarctica. These bioturbation processes also have implications for novel radiocarbon dating methods that have recently been developed to overcome sediment reworking processes and more accurately constrain timing of past AIS retreat, including ramped pyrolysis and compound specific isotopes methods.

keywords: Radiocarbon age; Young carbon; Bioturbation; Antarctica; Acid insoluble organic matter

2-4 Agriculture

Chronological changes in soil biogeochemical properties of the glacier foreland of Midtre Lovénbreen, Svalbard, attributed to soil-forming factors

Kim, You Jin., Laffly, Dominique., **Kim, Se-eun.**, Nilsen, Lennart., **Chi, Junhwa.**, **Nam, Sungjin.**, Lee, Yong Bok., **Jeong, Sujeong.**, Mishra, Umakant., **Lee, Yoo Kyung.** and **Jung, Ji Young.**

Geoderma. 2022. 415.

doi: 10.1016/j.geoderma.2022.115777

Glacier forelands provide an excellent opportunity to investigate vegetation succession and soil development along the chronosequence; however, there are few studies on soil biogeochemical changes from environmental factors, aside from time. This study aimed to investigate soil development and biogeochemical changes in the glacier foreland of Midtre Lovénbreen, Svalbard, by considering various factors, including time. Eighteen vegetation and soil variables were measured at 38 different sampling sites of varying soil age, depth, and glacio-fluvial activity. Soil organic matter (SOM) was quantitatively measured, and the compositional changes in SOM were determined following size-density fractionation. In the topsoil, the soil organic carbon (SOC) and total nitrogen (N) content was found to increase along the soil chronosequence and were highly correlated with vegetation-associated variables. These findings suggest that plant-derived material was the main driver of the light fraction of SOM accumulation in the topsoil. The heavy fractions of SOM were composed of microbially transformed organic compounds, eventually contributing to SOM stabilization within short 90-yr deglaciation under harsh climatic conditions. In addition to time, the soil vertical profiles showed that other environmental parameters, also affected the soil biogeochemical properties. The high total phosphorous (P) content and electrical conductivity in the topsoil were attributed to unweathered subglacial materials and a considerable amount of inorganic ions from subglacial meltwater. The high P and magnesium content in the subsoil were attributed to parent materials, while the high sodium and potassium content in the surface soil were a result of sea-salt deposition. Glacio-fluvial runoff hampered ecosystem development by inhibiting vegetation development and SOM accumulation. This study emphasizes the importance of considering various soil-forming factors,

including parent/subglacial materials, aeolian deposition, and glacio-fluvial runoff, as well as soil age, to obtain a comprehensive understanding of the ecosystem development in glacier forelands.

keywords: Glacier foreland; Soil-forming factors; Soil biogeochemical property; Chronosequence; Glacio-fluvial runoff; Svalbard

2-5 Physical Geography; Geology

Chronostratigraphy of the Larsen blue-ice area in northern Victoria Land, East Antarctica, and its implications for paleoclimate

Lee, Giyoon., Ahn, Jinho., **Ju, Hyeontae.**, Ritterbusch, Florian., Oyabu, Ikumi., Buizert, Christo., **Kim, Songyi.**, **Moon, Jangil.**, Ghosh, Sambit., Kawamura, Kenji., Lu, Zheng-Tian., **Hong, Sangbum.**, **Han, Chang Hee.**, **Hur, Soon Do.** and 2 others.

Cryosphere. 2022. 16(6): 2301-2324.

doi: 10.5194/tc-16-2301-2022

In blue-ice areas (BIAs), deep ice is directly exposed at the surface, allowing for the cost-effective collection of large-sized old-ice samples. However, chronostratigraphic studies on blue-ice areas are challenging owing to fold and fault structures. Here, we report on a surface transect of ice with an undisturbed horizontal stratigraphy from the Larsen BIA, northern Victoria Land, East Antarctica. Ice layers defined by dust bands and ground-penetrating radar (GPR) surveys indicate a monotonic increase in age along the ice flow direction on the downstream side, while the upstream ice exhibits a potential repetition of ages on scales of tens of meters, which result from a complicated fold structure. Stable water isotopes ($\delta^{18}\text{O}_{\text{ice}}$ and $\delta^2\text{H}_{\text{ice}}$) and components of the occluded air (i.e., CO_2 , N_2O , CH_4 , $\delta^{15}\text{N}-\text{N}_2$, $\delta^{18}\text{O}_{\text{atm}}$ ($=\delta^{18}\text{O}-\text{O}_2$), $\delta\text{O}_2/\text{N}_2$, $\delta\text{Ar}/\text{N}_2$, ^{81}Kr , and ^{85}Kr) are analyzed for surface ice and shallow ice core samples. Correlating $\delta^{18}\text{O}_{\text{ice}}$, $\delta^{18}\text{O}_{\text{atm}}$, and CH_4 records from the Larsen BIA with ice from previously drilled ice cores indicates that the gas age at various shallow vertical coring sites ranges between 9.2–23.4 kyr BP, while the ice age sampled from the surface ranges from 5.6 to 24.7 kyr BP. Absolute radiometric ^{81}Kr dating for the two vertical cores confirms ages within acceptable levels of analytical uncertainty. A tentative climate reconstruction suggests a large deglacial warming of $15 \pm 5^\circ\text{C}$ (1 σ) and an

increase in snow accumulation by a factor of 1.7–4.6 (from 24.3 to 10.6 kyr BP). Our study demonstrates that BIAs in northern Victoria Land may help to obtain high-quality records for paleoclimate and atmospheric greenhouse gas compositions through the last deglaciation, although in general climatic interpretation is complicated by the need for upstream flow corrections, evidence for strong surface sublimation during the last glacial period, and potential errors in the estimated gas age-ice age difference.

2-6 Chemistry

COM-1 and Hongcheon: New monazite reference materials for the microspot analysis of oxygen isotopic composition

Kim, Jeongmin., **Park, Changkun.** and 5 others.

Journal of Analytical Science and Technology. 2022. 13(1).

doi: 10.1186/s40543-022-00342-5

Background: Monazite, a moderately common light rare earth element (LREE) and thorium phosphate mineral, has chemical, age, and isotopic characteristics that are useful in the investigation of the origin and evolution of crustal melts and fluid-rock interactions. Multiple stages of growth and partial recrystallization commonly observed in monazite inevitably require microspot chemical and isotopic analyses, for which well-characterized reference materials are essential to correct instrumental biases. In this study, we introduce new monazite reference materials COM-1 and Hongcheon for the use in the microspot analysis of oxygen isotopic composition.

Findings: COM-1 and Hongcheon were derived from a late Mesoproterozoic (~1080 Ma) pegmatite dyke in Colorado, USA, and a Late Triassic (~230 Ma) carbonatite-hosted REE ore in central Korea, respectively. The COM-1 monazite has much higher levels of Th (8.77 ± 0.56 wt.%), Si (0.82 ± 0.07 wt.%) and lower REE contents (total REE = 49.5 ± 1.2 wt.%) than does the Hongcheon monazite (Th, 0.23 ± 0.11 wt.%; Si, < 0.1 wt.%; total REE, 59.9 ± 0.7 wt.%). Their oxygen isotopic compositions ($\delta^{18}\text{O}_{\text{VSMOW}}$) were determined by gas-source mass spectrometry with laser fluorination (COM-1, $6.67 \pm 0.08\text{‰}$; Hongcheon-1, $6.60 \pm 0.02\text{‰}$; Hongcheon-2, $6.08 \pm 0.07\text{‰}$). Oxygen isotope measurements performed by a Cameca IMS1300-HR³ ion probe showed a strong linear dependence ($R^2 = 0.99$) of the instrumental mass fractionation on the

total REE contents.

Conclusions: We characterized chemical and oxygen isotopic compositions of COM-1 and Hongcheon monazites. Their internal homogeneity in oxygen isotopic composition and chemical difference provide an efficient tool for calibrating instrumental mass fractionation occurring during secondary ion mass spectrometry analyses.

keywords: Monazite; Reference material; COM-1; Hongcheon; Oxygen isotopes; Instrumental mass fractionation

2-7 *Geology; Meteorology & Atmospheric Sciences*

Comparison between total least squares and ordinary least squares in obtaining the linear relationship between stable water isotopes

Lee, Jeonghoon., **Lee, Won Sang.**, Jung, Hyejung. and Lee, Seung-Gu.

Geoscience Letters. 2022. 9(1).

doi: 10.1186/s40562-022-00219-w

The linear relationship between two stable water isotopes (δD and $\delta^{18}O$) has been used to examine the physical processes and movements or changes of three water phases (water vapor, liquid water and ice), including deuterium excess. The ordinary least squares (OLS) method has been the most commonly used method to fit the linear relationship between two isotopic compositions of water. However, an alternative method, the total least squares (TLS) method, has been proposed because it considers the presence of errors in the explanatory variable (horizontal axis, $\delta^{18}O$). However, not many studies have examined the differences of the relationship using two stable isotopes between the OLS and TLS for various types of water. In this work, these two methods were compared using isotopic compositions of three types of water (Antarctic snow, water vapor and summer and winter rainfall). Statistically, the slopes and intercepts obtained by the two linear regression methods were not significantly different except for summer rainfall, which has the smallest coefficient of variations (R^2). The TLS method produced larger slopes than the OLS method and the degrees of difference between the two methods were greater when the coefficient of variation was lower. In addition, with a Monte Carlo method, we showed that the differences between the

two methods increased as the uncertainty increased. Moreover, the results of Bayesian linear regression were consistent with the two linear regressions. Although the TLS method is theoretically more suited to the linear regression for the stable water isotopes than the OLS method is, the application of the widely used OLS method can be recommended in the case of small measurements uncertainties after testing whether the linear parameters, slopes and intercepts, derived from the two methods are statistically significant different.

keywords: Ordinary least squares; Total least squares; Stable water isotopes; Monte Carlo

2-8 *Geology; Oceanography; Paleontology*

A Comparison of Methods for Identifying and Quantifying Ice Rafted Debris on the Antarctic Margin

McKay, Robert., Albot, Olga., Dunbar, Gavin B., **Lee, Jae Il., Lee, Min Kyung., Yoo, Kyu-Cheul., Kim, Sunghan.** and 4 others.

Paleoceanography and Paleoclimatology. 2022. 37(4).

doi: 10.1029/2021pa004404

Quantification of ice rafted debris (IRD) abundances in deep-sea records is often used as a key proxy for identifying links between ice sheet instability and the oceanic overturning circulation. There currently exist multiple methods to determine IRD content in deep-sea sediment cores. The preference for a given method is often determined by the accessibility to core material and destructive nature of some methods. While many studies have discussed the caveats between linking IRD to ice sheet dynamics, the uncertainties relating to the methodological approaches are often not considered in the interpretation or comparisons between different IRD datasets, particularly in the Antarctic. To address this, we compare three independent methodologies of obtaining IRD abundances and also discuss how different approaches will affect determinations of mass accumulation rates (MARs). The three methodologies we examine include: counting clasts >2 mm in x-radiographs; the sieved weight percentage of the medium-to-coarse sand fraction (250 μm –2 mm); and volumetric estimates of the >125 μm sand fraction using laser diffraction particle size analysis. The x-radiograph and sieve methods produced

comparable results, while the laser particle size analysis, although showing comparable long-term signals at most locations, in general has lower correlation to the other two methods and therefore a higher potential to obtain a noisy signal. We discuss the caveats associated with all methods, and emphasize that a combination of multiple methods should ideally be employed when assessing if a core is suitable for IRD study, and if sand or gravel fractions are accurately reflecting contents of IRD.

2-9 Geology

Correction for Na Migration Effects in Silicate Glasses During Electron Microprobe Analysis

Kim, Hwayoung. and **Park, Changkun.**

Korean Journal of Mineralogy and Petrology. 2022. 35(4): 457-467.

doi: 10.22807/KJMP.2022.35.4.457

Electron bombardment to silicate glass during electron probe microanalysis (EPMA) causes outward migration of Na from the excitation volume and subsequent decrease in the measured X-ray count rates of Na. To acquire precise Na₂O content of silicate glass, one should use proper analytical technique to avoid or minimize Na migration effect or should correct for decreases in the measured Na X-ray counts. In this study, we analyzed 8 silicate glass standard samples using automated Time Dependent Intensity (TDI) correction method of Probe for EPMA software that can calculate zero-time intercept by extrapolating X-ray count changes over analysis time. We evaluated an accuracy of TDI correction for Na measurements of silicate glasses with EPMA at 15 kV acceleration voltage and 20 nA probe current electron beam, which is commonly utilized analytical condition for geological samples. Results show that Na loss can be avoided with 20 μ m sized large beam (<0.1 nA/ μ m²), thus silicate glasses can be analyzed without TDI correction. When the beam size is smaller than 10 μ m, Na loss results in large relative errors up to -55% of Na₂O values without correction. By applying TDI corrections, we can acquire Na₂O values close to the reference values with relative errors of $\sim \pm 10\%$. Use of weighted linear-fit can reduce relative errors down to $\pm 6\%$. Thus, quantitative analysis of silicate glasses with EPMA is required for TDI correction for alkali elements such as Na and K.

keywords: EPMA; Electron microprobe; Silicate glass; Na migration; TDI correction

2-10 Physical Geography; Geology

Cyclic sediment deposition by orbital forcing in the Miocene wetland of western Amazonia? New insights from a multidisciplinary approach

Carina, Hoorn., Tyler, Kukla., Giovanni ,Bogota-Angel., Els van, Soelen., Catalina, Gonzalez-Arango., Frank P., Wesselingh., Hubert, Vonhof., Pedro, Val., Gaspar, Morcote-Rios., Martin, Roddaz., Elton Luiz, Dantas., Roberto, Ventura Santosl., Jaap S., Sinninghe Damst'e., **Kim, Jung-Hyun.** and Robert J. Morley.

Global and Planetary Change. 2022. 210(1)

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In the Miocene, a large wetland system extended from the Andean foothills into western Amazonia. This system has no modern analogue and the driving mechanisms are not yet fully understood. Dynamic topography and Andean uplift are thought to have controlled deposition, with allocyclic base level changes driven by eustasy and orbital forcing also playing a role. In this study we investigate the presumed orbital cyclicity that controlled sediment deposition, while also assessing sediment source and biomes in the Miocene wetland. We do this by integrating lithological, palynological, malacological and geochemical data from the Los Chorros site (Amazon River, Colombia), and by placing our data in a sequence stratigraphic framework. In this sequence biostratigraphic evaluation, the Los Chorros succession is visualized to be composed of a series of flood-fill packages, with a rapid initial flood, marine-influenced conditions at the time of maximum flood, followed by a longer regressive infill phase. Based on the palynology we could differentiate local vegetation, such as palm swamps, from regional origin such as terra firme vegetation (non-flooded Amazonian forest) and Andean montane forest, while from sediment geochemistry we could separate local and regional sediment sources. At the times of flooding, oligotrophic and eutrophic aquatic conditions alternatively characterized the wetland, as is shown by the presence of algae, floating ferns, and mollusc assemblages, while intervening subaquatic debris points to proximal submerged lowlands. In the lower 20 m of the section, marine influences are

intermittently evident and shown by short-lived maxima of mangrove pollen, foraminiferal test linings, dinoflagellate cysts, coastal mollusc species, and an episodic decline in terrestrial biomarkers. The upper 5 m of the section is characterized by floodplain forest taxa with a diversity in tropical rain forest taxa and relatively few lacustrine indicators. These marine, mangrove, and lacustrine indicators suggest that the outcrops at Los Chorro represent predominant marine-influenced lacustrine conditions during periods of sea level highstand. The sequence biostratigraphic evaluation further points to eight 41 kyr obliquity-driven depositional cycles, with rapid phases of transgression. Mangrove elements would have colonised within the timeframe of each sea level rise. Based on this relative age constraint and comparison to regional records, deposition likely took place prior to the 13.8 Myr global sea level fall, and most likely during the period just after 14.5 Ma, between Middle Miocene Climatic Optimum (MMCO; 17–14 Ma) and Middle Miocene Climate Transition (MMCT; 14.7–13.8 Ma). Palynological evidence further suggests that to the west, surface elevation ranged from ~1000 up to ~3500 m and hosted protoparamo vegetation, the oldest yet reported and in agreement with predictions from molecular studies. In contrast, contemporaneous sites to the northeast of the wetland consisted of fluvial and cratonic formations, as shown by their Nd and Sr isotopic sediment signature. In summary, our data lead to an improved understanding of how geological and astronomical mechanisms controlled the floral and faunal distribution and controlled sediment deposition in western Amazonia during the middle Miocene. As Miocene conditions strongly contrast with modern western Amazonia, our data provide an important context for the deep time history and evolution of the modern western Amazon rainforest.

keywords: Amazon palynology; Sequence stratigraphy, geochemistry; Biomarkers; Estuarine; Marine incursions

Changes in ice shelf dynamics significantly impact the discharge rate of grounded ice, sea ice formation, and marine environments. In particular, changes of a sub-shelf pinning point induce complex dynamics of an ice shelf. In this study, we investigated decadal changes (2010–2020) in the area, ice velocity, and grounding line position of Campbell Glacier Tongue (CGT) in East Antarctica, which has an ice pinning point at the southwestern end, and analyzed the effect of the pinning conditions on the dynamics of CGT. Panchromatic band images of Landsat-7 Enhanced Thematic Mapper Plus and Landsat-8 Operational Land Imager, COSMO-SkyMed X-band synthetic aperture radar (SAR), and Sentinel-1 C-band SAR datasets were employed. The surface area of CGT digitized from the optical and SAR imagery decreased by 8% in the last decade, during which four ice calving events that caused icebergs with an area range of 3.8–5.4 km². The largest calving at the ice pinning point occurred in March 2014, which created an iceberg with 4 km². The ice velocity of CGT was measured via the normalized cross-correlation-based image matching of the Landsat panchromatic images. The ice velocity along the flow direction and its anomaly of CGT hardly changed in the hinge zone from 2011 to 2020. The ice velocity increased by ~7% and the flow direction steered abruptly ~7° to the east in the freely floating zone after the 2014 calving at the ice pinning point. Considering the retreat of the local grounding line at the pinning point analyzed by COSMO-SkyMed double-differential interferometric SAR, the advancing glacier tongue came in contact with the sloping eastern flank of the locally elevated seabed at the pinning point after the calving, and the ice-bed contact area decreased, causing a sudden acceleration and eastward rotation of ice flow. It is expected that continuous calving at the ice pinning point of CGT may lead to an abrupt changes in glacier tongue dynamics again, and continuous monitoring is necessary.

keywords: SAR; optical; Campbell Glacier Tongue; ice velocity; ice calving; ice pinning point

2-11 Physical Geography; Remote Sensing

Decadal changes of Campbell Glacier Tongue in East Antarctica from 2010 to 2020 and implications of ice pinning conditions analyzed by optical and SAR datasets

Han, Hyangsun., Kim, Seung Hee. and Kim, Sanghee.

Giscience & Remote Sensing. 2022. 59(1): 705-721.

doi: 10.1080/15481603.2022.2055380

2-12 Science & Technology

Deglacial release of petrogenic and permafrost carbon from the Canadian Arctic impacting the carbon cycle

Wu, Junjie., Mollenhauer, Gesine., Stein, Ruediger., Kohler, Peter., Hefter, Jens., Fahl, Kirsten., Grotheer, Hendrik., Wei, Bingbing. and Nam, Seung-Il.

Nature Communications. 2022. 13(1).

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The changes in atmospheric $p\text{CO}_2$ provide evidence for the release of large amounts of ancient carbon during the last deglaciation. However, the sources and mechanisms that contributed to this process remain unresolved. Here, we present evidence for substantial ancient terrestrial carbon remobilization in the Canadian Arctic following the Laurentide Ice Sheet retreat. Glacial-retreat-induced physical erosion of bedrock has mobilized petrogenic carbon, as revealed by sedimentary records of radiocarbon dates and thermal maturity of organic carbon from the Canadian Beaufort Sea. Additionally, coastal erosion during the meltwater pulses 1a and 1b has remobilized pre-aged carbon from permafrost. Assuming extensive petrogenic organic carbon oxidation during the glacial retreat, a model-based assessment suggests that the combined processes have contributed 12 ppm to the deglacial CO_2 rise. Our findings suggest potentially positive climate feedback of ice-sheet retreat by accelerating terrestrial organic carbon remobilization and subsequent oxidation during the glacial-interglacial transition.

keywords: Canadian Arctic; Carbon cycle; Deglaciation & YD; Permafrost; Petrogenic carbon

some tillites correlatable with the Lanterman Formation in northern Victoria Land to identify the source regions of these glaciogenic deposits. Six-hundred detrital zircon grains from four diamictite samples were analyzed using laser ablation-inductively coupled plasma-mass spectrometry. Geochronological and petrographic compositional data of the Metschel Tillite indicate a widespread reworking of older Devonian Beacon Super-group sedimentary strata, with minor contribution from Cambro-Ordovician granitoids and meta-sedimentary units as well as Neoproterozoic metamorphic rocks. Euhedral to subhedral Carboniferous-Devonian zircon grains match coeval magmatic units of northern Victoria Land and Marie Byrd Land. This implies, in accordance with published paleo-ice directions, a provenance from the east-southeast sectors. In contrast, the two samples from northern Victoria Land tillite reflect the local basement provenance; their geochronological age and petrographic composition indicates a restricted catchment area with multiple ice centers. This shows that numerous ice centers were present in southern Gondwana during the Late Paleozoic Ice Age. While northern Victoria Land hosted discrete glaciers closely linked with the northern Victoria Land-Tasmania ice cap, the west-northwestward flowing southern Victoria Land ice cap contributed most of the sediments comprising the Metschel Tillite.

2-13 Geology

Detrital zircons from Late Paleozoic Ice Age sequences in Victoria Land (Antarctica): New constraints on the glaciation of southern Gondwana

Zurli, Luca., Cornamusini, Gianluca., Woo, Jusun., Liberato, Giovanni Pio., **Han, Seunghee.** and 2 others.

Geological Society of America Bulletin. 2022. 134(1-2): 160-178.

doi: 10.1130/b35905.1

The Lower Permian tillites of the Beacon Supergroup, cropping out in Victoria Land (Antarctica), record climatic history during one of the Earth's coldest periods: the Late Paleozoic Ice Age. Reconstruction of ice-extent and paleo-flow directions, as well as geochronological and petrographic data, are poorly constrained in this sector of Gondwana. Here, we provide the first detrital zircon U-Pb age analyses of both the Metschel Tillite in southern Victoria Land and

2-14 Pharmacology & Pharmacy

Discovery and Photoisomerization of New Pyrrolosequiterpenoids Glaciapyrroles D and E, from Deep-Sea Sediment *Streptomyces* sp

Ko, Keebeom., Kim, Seong-Hwan., Park, Subin., Han, Hwa Seung., Lee, Jae Kyun., Cha, Jin Wook., Hwang, Sunghoon., Choi, Ki Young., Song, Yoon-Jae., Nam, Sang-Jip., Shin, Jongheon., **Nam, Seung-Il.** and 3 others.

Marine Drugs. 2022. 20(5).

doi: 10.3390/md20050281

Two new pyrrolosequiterpenes, glaciapyrroles D (1) and E (2) were discovered along with the previously reported glaciapyrrole A (3) from *Streptomyces* sp. GGS53 strain isolated from deep-sea sediment. This study elucidated the planar structures of 1 and 2 using nuclear magnetic resonance (NMR), mass spectrometry (MS), ultraviolet (UV), and infrared (IR) spectroscopic data. The absolute configurations of the glaciapyrroles

were determined by Mosher's method, circular dichroism spectroscopy, and X-ray crystallography. Under 366 nm UV irradiation, the glaciapyrroles were systematically converted to the corresponding photoglaciapyrroles (4–6) via photoisomerization, resulting in the diversification of the glaciapyrrole family compounds. The transformation of the glaciapyrrole *Z* to *E* isomers occurred in a 1:1 ratio, based on virtual validation of the photoisomerization of these olefinic compounds by ¹H-NMR spectroscopy and liquid chromatography/mass spectrometry (LC/MS) analysis. Finally, when encapsulated in poly (lactic-co-glycolic acid) nanoparticles, glaciapyrrole *E* and photoglaciapyrrole *E* displayed significant inhibitory activity against influenza A virus. This is the first report of antiviral effects from glaciapyrrole family compounds, whose biological functions have only been subjected to limited studies so far.

keywords: Streptomyces; glaciapyrrole; deep-sea sediment; structure elucidation; photoisomerization; pyrrolonesquiterpene

2-15 Geology

Estimation of the gas hydrate saturation from multichannel seismic data on the western continental margin of the Chukchi Rise in the Arctic Ocean

Choi, Yeonjin., Kang, Seung-Goo., Jin, Young Keun., Hong, Jong Kuk., Shin, Sung-Ryul., Kim, Sookwan. and Choi, Youngil.

Frontiers in Earth Science. 2022. 10.

doi: 10.3389/feart.2022.1025110

A multichannel seismic survey was conducted to investigate the geophysical characteristics of gas hydrates along the western continental margin of the Chukchi Rise around an ARAON mound cluster, which was first recovered in 2016. In the seismic data, gas hydrate-related bottom simulating reflection was widely distributed along the western continental margin of the Chukchi Rise. High-precision seismic P-wave velocity was obtained to investigate the geophysical characteristics of the gas hydrate structures in the BSR areas. Iterative migration velocity analysis was used to construct a detailed P-wave velocity model from the acquired seismic data. The gas hydrate and free gas layers have abnormally high- and low-seismic P-wave velocities; the precise velocity

model allows us to understand the detailed spatial distribution of gas hydrate and free gas structures. The effective medium theory model enables estimations of the gas hydrate saturation from constructed seismic P-wave velocity model. We propose the P-wave velocity and gas hydrate saturation models from acquired multichannel seismic data in the western continental margin of the Chukchi Rise for the first time.

keywords: gas hydrates along the western continental margin of the chukchi rise in the arctic ocean; bottom simulating reflections (BSRs); seismic P-wave velocity model; iterative migration velocity analysis; estimation of gas hydrate saturation by the effective medium theory (EMT) model; characteristic of free gas-bearing sediment

2-16 Science & Technology

First asteroid gas sample delivered by the Hayabusa2 mission: A treasure box from Ryugu

Okazaki, Ryuji., Miura, Yayoi N., Takano, Yoshinori., Sawada, Hiroataka., Sakamoto, Kanako., Yada, Toru., Yamada, Keita., Kawagucci, Shinsuke., Matsui, Yohei., Hashizume, Ko., Ishida, Akizumi., Broadley, Michael W., Marty, Bernard., Byrne, David., Furi, Evelyn., Meshik, Alex., Pravdivtseva, Olga., Busemann, Henner., Riebe, My E. I., Gilmour, Jamie., Park, Jisun., Bajo, Ken-ichi., Righter, Kevin., Sakai, Saburo., Sekimoto, Shun., Kitajima, Fumio., Crowther, Sarah A., Iwata, Naoyoshi., Shirai, Naoki., Ebihara, Mitsuru., Yokochi, Reika., Nishiizumi, Kuniyuki., Nagao, Keisuke., Lee, Jong Ik. and 90 others.

Science Advances. 2022. 8(46).

doi: 10.1126/sciadv.abo7239

The Hayabusa2 spacecraft returned to Earth from the asteroid 162173 Ryugu on 6 December 2020. One day after the recovery, the gas species retained in the sample container were extracted and measured on-site and stored in gas collection bottles. The container gas consists of helium and neon with an extraterrestrial ³He/⁴He and ²⁰Ne/²²Ne ratios, along with some contaminant terrestrial atmospheric gases. A mixture of solar and Earth's atmospheric gas is the best explanation for the container gas composition. Fragmentation of Ryugu grains within the sample container is discussed on the basis of the estimated amount of indigenous He and the size distribution of the recovered Ryugu grains. This is the first successful return of gas species from a near-Earth asteroid.

2-17 *Geology*

Glacial history and depositional environments in little Storfjorden and Hambergbukta of Arctic Svalbard since the younger dryas

Joe, Young Jin., Jang, Kwangchul., Forwick, Matthias., Laberg, Jan Sverre., Kong, Gee Soo., Kang, Moo-Hee., Yoon, Seok-Hoon. and **Nam, Seung-Il.**

Frontiers in Earth Science. 2022. 10.

doi: 10.3389/feart.2022.1017594

Geophysical and lithological data provide crucial information for the understanding of glacial history in Arctic Svalbard. In this study, we reconstructed the glacier-induced depositional environments of Little Storfjorden and its tributary, Hambergbukta, over the last 13 ka to better understand the glacial history of southeastern Svalbard. The combined uses of swath-bathymetry, high-resolution seismic stratigraphy, and multiple-proxy measurements of sediment cores allowed us to define five steps of glacier-induced depositional environments: 1) deposition of massive, semi-consolidated gravelly sandy mud (Facies 1) during re-advance or still-stand of the marine-based glaciers/ice streams in Little Storfjorden during Younger Dryas (13–12 ka); 2) deposition of massive mud to gravelly sandy mud (Facies 2A and B) during glacial retreat until the earliest Holocene (12–10.1 ka); 3) sediment winnowing by enhanced bottom currents during the early to middle Holocene (10.1–3.7 ka); 4) deposition of bioturbated sandy mud (Facies 3) with high productivity under seasonal sea ice conditions during the late Holocene (3.7–0.7 ka); and 5) deposition of (slightly) bioturbated sandy to gravelly mud (Facies 4) affected by glacier surges since Little Ice Age (LIA) (Facies 4). In addition to seismic stratigraphy, depositional patterns of IRD in Little Storfjorden indicate that the glacier surges in Hambergbukta occurred only after ~0.7 ka. This suggests that the terminal moraine complex (TMC) represents the maximum extent of the LIA surges, which argues against the recent inference for the TMC formation during pre-LIA. This study shows the importance of multiple parameters to better understand the current behavior of tidewater glaciers in the Svalbard fjords in response to rapid climate change.

keywords: Grounding zone wedge; Hambergbukta; Little Ice Age; Little Storfjorden; Terminal moraine; Younger Dryas

2-18 *Geology*

Glacial Ice Melting Stimulates Heterotrophic Prokaryotes Production on the Getz Ice Shelf in the Amundsen Sea, Antarctica

Min, Jun-Oh., Kim, Sung-Han., **Jung, Jinyoung.,** Jung, Ui-Jung., **Yang, Eun Jin.,** **Lee, SangHoon.** and Hyun, Jung-Ho.

Geophysical Research Letters. 2022. 49(19).

doi: 10.1029/2021gl097627

Extensive oceanographic data sets were combined with microbiological parameters to elucidate the tight coupling between glacial meltwater and heterotrophic bacterial production (BP) on the Getz Ice Shelf (GtzIS) in the Amundsen Sea. BP in the eastern GtzIS (EG; 85.8 pM Leu. h⁻¹), where basal glacier meltwater upwells, was significantly higher than BP measured in the western GtzIS (WG; 50.6 pM Leu. h⁻¹) and the Amundsen Sea Polynya (ASP; 27.8 pM Leu. h⁻¹). BP in the EG accounted for 49% of primary production, which was greater than that of the WG (10%) and ASP (9.2%). Enhanced BP in the eastern GtzIS was not coupled with phytoplankton biomass, but correlated significantly with the freshwater fraction containing meltwater-derived dissolved organic carbon (MW-DOC). These results suggest that warming-induced glacier melting weakens carbon sequestration efficiency in Antarctic coastal waters by stimulating heterotrophic metabolism that converts MW-DOC to CO₂.

keywords: bacterial production; microbial loop; Getz Ice Shelf; DOC; meltwater; Amundsen Sea

2-19 *Geochemistry & Geophysics*

Heterogeneous Fossil Réunion Plume Component in the Source Region of Enriched MORB Along the Central Indian Ridge Between 12° and 17°S

Vincent, Clement., Park, Jung-Woo., Lee, Sang-Mook., Kim, Jonguk., **Lee, Mi-Jung.** and Revillon, Sidonie.

Journal of Geophysical Research-Solid Earth. 2022. 127(12).

doi: 10.1029/2022jb025379

Mid-ocean ridge basalts (MORB) from the Central Indian Ridge (CIR) between 12° and 17°S show a wide range of geochemical and isotopic variations. Particularly, MORB from a segment between 14° and

15°S are more enriched in incompatible trace elements with more radiogenic Sr and Pb isotope and unradiogenic Nd isotope values than the lavas between 15° and 16°S with geochemical features of normal MORB. However, the causes for the enrichment between 14° and 15°S are poorly constrained. In this study, we re-examined the CIR MORB from 12° to 17°S with new geochemical data obtained based on high spatial resolution sampling to better understand the nature of the enriched mantle source. Our new geochemical data show that the MORB between 14° and 15°S, with maximum values for $(\text{La}/\text{Sm})_{\text{N}} = 1.95$, $^{87}\text{Sr}/^{86}\text{Sr} = 0.703526$ and $^{206}\text{Pb}/^{204}\text{Pb} = 18.7558$, are more enriched than those from the southern segments (16° to 20°S) known to be influenced by the Réunion mantle component. The new trace element and isotopic compositions of MORB suggest that three mantle end-members are required to explain the geochemical variations shown between 14° and 16°S: the depleted Indian-type MORB mantle, Réunion Plume (RP), and Seychelles/Madagascar-like continental crust components. Moreover, our mixing model suggests that the differences in enriched MORB signature from 14° to 20°S are due to variable proportions of continental material previously mixed with the RP. Our study implies that a continental component interacted with the plume into the asthenosphere, possibly beneath Madagascar or below Mauritius Island and the Mascarene plateau.

keywords: Central Indian Ridge; E-MORB; mantle heterogeneity; Réunion plume

and algorithms. However, hyperspectral data are usually limited by their narrow, highly correlated and contiguous spectral bands in both processing and analysis. Moreover, the resolution of available hyperspectral datasets is not sufficiently high for the identification of small objects. Nevertheless, with the rapidly advancing technology, hyperspectral imaging systems can now be mounted on small aerial vehicles for detecting small objects at low altitude. To properly handle these high spectral and spatial resolution data, new or redesigned data processing or analysis pipelines must be developed, but such datasets are limited. In this study, we describe two hyperspectral datasets acquired by a drone and evaluate their radiometric and geometric quality. Based on appropriate data acquisition and processing approaches, our datasets are expected to be useful as testbeds for new algorithms and applications.

keywords: geometric correction; hyperspectral; permafrost; radiometric correction; unmanned aerial vehicle

2-20 *Geology; Meteorology & Atmospheric Sciences*

High-resolution hyperspectral imagery from pushbroom scanners on unmanned aerial systems

Kim, Jae-In., **Chi, Junhwa.**, Masjedi, Ali., Flatt, John Evan., Crawford, Melba M., Habib, Ayman F., **Lee, Joohan. and Kim, Hyun-Cheol.**

Geoscience Data Journal. 2022. 9(2): 221-234.

doi: 10.1002/gdj3.133

Hyperspectral data are gaining popularity in remote sensing and signal processing communities because of the increased spectral information relative to multispectral data. Several airborne and spaceborne hyperspectral datasets are publicly available, facilitating the development of various applications

2-21 *Crystallography; Materials Science*

Identification, Characterization, and Preliminary X-ray Diffraction Analysis of a Novel Esterase (ScEst) from *Staphylococcus chromogenes*

Hwang, Jisub., Jeon, Sangeun., **Lee, Min Ju.**, Yoo, Wanki., Chang, Juwon., Kim, Kyeong Kyu., **Lee, Jun Hyuck, Do, Hackwon.** and Kim, T. Doohun.

Crystals. 2022. 12(4).

doi: 10.3390/cryst12040546

Ester prodrugs can develop novel antibiotics and have potential therapeutic applications against multiple drug-resistant bacteria. The antimicrobial activity of these prodrugs is activated after being cleaved by the esterases produced by the pathogen. Here, novel esterase ScEst originating from *Staphylococcus chromogenes* NCTC10530, which causes dairy cow mastitis, was identified, characterized, and analyzed using X-ray crystallography. The gene encoding ScEst was cloned into the pVFT1S vector and overexpressed in *E. coli*. The recombinant ScEst protein was obtained by affinity and size-exclusion purification. ScEst showed substrate preference for the short chain length of acyl derivatives. It was crystallized in an optimized solution composed of 0.25 M ammonium citrate tribasic (pH 7.0)

and 20% PEG 3350 at 296 K. A total of 360 X-ray diffraction images were collected at a 1.66 Å resolution. ScEst crystal belongs to the space group of $P2_12_12_1$ with the unit cell parameters of $a = 50.23$ Å, $b = 68.69$ Å, $c = 71.15$ Å, and $\alpha = \beta = \gamma = 90^\circ$. Structure refinement after molecular replacement is under progress. Further biochemical studies will elucidate the hydrolysis mechanism of ScEst. Overall, this study is the first to report the functional characterization of an esterase from *Staphylococcus chromogenes*, which is potentially useful in elaborating its hydrolysis mechanism.

keywords: carboxylesterase; *Staphylococcus chromogenes*; X-ray crystallography

2-22 Crystallography; Materials Science

Identification, Characterization, and Preliminary X-ray Diffraction Analysis of a Single Stranded DNA Binding Protein (LjSSB) from Psychrophilic *Lacinutrix jangbogonensis* PAMC 27137

Choi, Woong., Son, Jonghyeon., Park, Aekyung., **Jin, Hongshi.**, **Shin, Seung Chul.**, **Lee, Jun Hyuck.**, Kim, T. Doohun. and **Kim, Han-Woo.**

Crystals. 2022. 12(4).

doi: 10.3390/cryst12040538

Single-stranded DNA-binding proteins (SSBs) are essential for DNA metabolism, including repair and replication, in all organisms. SSBs have potential applications in molecular biology and in analytical methods. In this study, for the first time, we purified, structurally characterized, and analyzed psychrophilic SSB (LjSSB) from *Lacinutrix jangbogonensis* PAMC 27137 isolated from the Antarctic region. LjSSB has a relatively short amino acid sequence, consisting of 111 residues, with a molecular mass of 12.6 kDa. LjSSB protein was overexpressed in *Escherichia coli* BL21 (DE3) and analyzed for binding affinity using 20- and 35-mer deoxythymidine oligonucleotides (dT). In addition, the crystal structure of LjSSB at a resolution 2.6 Å was obtained. The LjSSB protein crystal belongs to the space group C222 with the unit cell parameters of $a = 106.58$ Å, $b = 234.14$ Å, $c = 66.14$ Å. The crystal structure was solved using molecular replacement, and subsequent iterative structure refinements and model building are currently under progress. Further, the complete structural information of LjSSB will provide a

novel strategy for protein engineering and for the application on molecular biological techniques.

keywords: single stranded DNA binding protein; *Lacinutrix jangbogonensis* PAMC 27137; X-ray crystallography

2-23 Geology

Impact of anthropogenic inputs on Pb content of moss *Sanionia uncinata* (Hedw.) Loeske in King George Island, West Antarctica revealed by Pb isotopes

Choi, Hye-Bin., Lim, Hyoun Soo., Yoon, Young-Jun., Kim, Ji-Hoon., **Kim, Ok-Sun.** and 2 others.

Geosciences Journal. 2022. 26(2): 225-234.

doi: 10.1007/s12303-021-0032-4

The accumulation of heavy metals in plant communities has been investigated in the maritime Antarctica but their sources are not clearly identified yet. Here we measured Pb isotope ratios in the mosses *Sanionia uncinata* (Hedw.) Loeske, soils and bedrocks on King George Island, South Shetland Islands, West Antarctica in order to elucidate the sources of Pb in the moss samples. The enrichment factor of Pb indicated that the moss samples near the research station and oil tank are highly enriched in Pb which is attributed to either leaded gasoline and/or Patagonian aeolian dust. However, Pb isotope ratios clearly indicated that leaded gasoline is the main source of Pb in the moss within 1 km from the station and that chemical weathering of soil and bedrock controls Pb content in the moss far from the station (over 1 km from the station). This study clearly demonstrated that Pb in plant communities, especially moss *Sanionia uncinata* (Hedw.) Loeske, on King George Island is mainly originated from a mixture of leaded gasoline and chemical weathering with a little effect of Patagonian aeolian dust.

keywords: moss *Sanionia uncinata* (Hedw.) Loeske; Pb isotopes; leaded gasoline; chemical weathering; King Sejong Station; Antarctica

The International Bathymetric Chart of the Southern Ocean Version 2

Dorschel, Boris., Hehemann, Laura., Viquerat, Sacha., Warnke, Fynn., Dreutter, Simon., Tenberge, Yvonne Schulze., Accettella, Daniela., An, Lu., Barrios, Felipe., Bazhenova, Evgenia., Black, Jenny., Bohoyo, Fernando., Davey, Craig., De Santis, Laura., Dotti, Carlota Escutia., Fremand, Alice C., Fretwell, Peter T., Gales, Jenny A., Gao, Jinyao., Gasperini, Luca., Greenbaum, Jamin S., Jencks, Jennifer Henderson., Hogan, Kelly., **Hong, Jong Kuk.** and 36 others.

Scientific Data. 2022. 9(1).

doi: 10.1038/s41597-022-01366-7

The Southern Ocean surrounding Antarctica is a region that is key to a range of climatic and oceanographic processes with worldwide effects, and is characterised by high biological productivity and biodiversity. Since 2013, the International Bathymetric Chart of the Southern Ocean (IBCSO) has represented the most comprehensive compilation of bathymetry for the Southern Ocean south of 60°S. Recently, the IBCSO Project has combined its efforts with the Nippon Foundation – GEBCO Seabed 2030 Project supporting the goal of mapping the world's oceans by 2030. New datasets initiated a second version of IBCSO (IBCSO v2). This version extends to 50°S (covering approximately 2.4 times the area of seafloor of the previous version) including the gateways of the Antarctic Circumpolar Current and the Antarctic circumpolar frontal systems. Due to increased (multibeam) data coverage, IBCSO v2 significantly improves the overall representation of the Southern Ocean seafloor and resolves many submarine landforms in more detail. This makes IBCSO v2 the most authoritative seafloor map of the area south of 50°S.

Lithium Isotope Geochemistry in the Barton Peninsula, King George Island, Antarctica

Ryu, Jong-Sik., Lim, Hyoun Soo., Choi, Hye-Bin., Kim, Ji-Hoon., **Kim, Ok-Sun.** and Vigier, Nathalie.

Frontiers in Earth Science. 2022. 10.

doi: 10.3389/feart.2022.913687

Lithium (Li) has two stable isotopes, ^6Li and ^7Li , whose large relative mass difference is responsible for significant isotopic fractionation during physico-

chemical processes, allowing Li isotopes to be a good tracer of continental chemical weathering. Although physical erosion is dominant in the Polar regions due to glaciers, increasing global surface temperature may enhance chemical weathering, with possible consequences on carbon biogeochemical cycle and nutriment flux to the ocean. Here, we examined elemental and Li isotope geochemistry of meltwaters, suspended sediments, soils, and bedrocks in the Barton Peninsula, King George Island, Antarctica. Li concentrations range from 8.7 nM to 23.3 μM in waters, from 0.01 to 1.43 ppm in suspended sediments, from 9.56 to 36.9 ppm in soils, and from 0.42 to 28.3 ppm in bedrocks. $\delta^7\text{Li}$ values are also variable, ranging from +16.4 to +41.1‰ in waters, from -0.4 to +13.4‰ in suspended sediments, from -2.5 to +6.9‰ in soils, and from -1.8 to +11.7‰ in bedrocks. Elemental and Li isotope geochemistry reveals that secondary phase formation during chemical weathering mainly control dissolved $\delta^7\text{Li}$ values, rather than a mixing with sea salt inputs from atmosphere or ice melting. Likewise, $\delta^7\text{Li}$ values of suspended sediments and soils lower than those of bedrocks indicate modern chemical weathering with mineral neoformation. This study suggests that increasing global surface temperature enhances modern chemical weathering in Antarctica, continuing to lower $\delta^7\text{Li}$ values in meltwater with intense water-rock interactions.

keywords: Li isotopes; chemical weathering; meltwater; mineral neoformation; Antarctica

Metalloenzyme signatures in authigenic carbonates from the Chukchi Borderlands in the western Arctic Ocean

Lee, Dong-Hun., **Kim, Jung-Hyun.**, **Lee, Yung Mi.**, Bayon, Germain., **Kim, Dahae.**, **Joe, Young Jin.**, Wang, Xudong., Shin, Kyung-Hoon. and **Jin, Young Keun.**

Scientific Reports. 2022. 12(1).

doi: 10.1038/s41598-022-21184-6

Migration of methane-rich fluids at submarine cold seeps drives intense microbial activity and precipitation of authigenic carbonates. In this study, we analyzed microbially derived authigenic carbonate samples recently recovered from active gas hydrate mounds on the southwestern slope of the Chukchi Borderlands (CB), western Arctic Ocean. Our main aim was to

characterize the distribution patterns of trace elements in carbonate-hosted lipid fractions to assess metalloenzyme requirements of microbes involved in anaerobic oxidation of methane (AOM). We measured stable isotopes, trace elements, lipid biomarkers, and genomic DNA, and results indicate the dominance of AOM-related lipid biomarkers in studied carbonate samples, as well as a predominant occurrence of the anaerobic methanotrophic archaea (ANME)-1. We also report evidence for significant preferential enrichments of various trace elements (Li, Ni, Co, Cu, Zn, and Mo) in the total lipid fractions of CB carbonates, relative to elemental compositions determined for corresponding carbonate fractions, which differ from those previously reported for other seep sites. We hypothesize that trace element enrichments in carbonate-hosted lipid fractions could vary depending on the type of AOM microbial assemblage. Additional work is required to further investigate the mechanisms of lipid-bound trace elements in cold seep carbonates as potential metalloenzymes in AOM.

keywords: Chukchi Borderlands; Metalloenzyme; anaerobic oxidation of methane; authigenic carbonates; western Arctic Ocean

2-27 Geology

Metamorphism obscures primary taphonomic pathways in the early Cambrian Sirius Passet Lagerstätte, North Greenland

Nielsen, Morten Lunde., **Lee, Mirinae.**, Ng, Hong Chin., Rushton, Jeremy C., Hendry, Katharine R., **Kihm, Ji-Hoon.**, Nielsen, Arne T., **Park, Tae-Yoon S.** and 2 others.

Geology. 2022. 50(1): 4-9.

doi: 10.1130/g48906.1

Correct interpretation of soft-bodied fossils relies on a thorough understanding of their taphonomy. While the focus has often been on the primary roles of decay and early diagenesis, the impacts of deeper burial and metamorphism on fossil preservation are less well understood. We document a sequence of late-stage mineral replacements in panarthropod fossils from the Sirius Passet Lagerstätte (North Greenland), an important early Cambrian Burgess Shale-type (BST) biota. Muscle and gut diverticula were initially stabilized by early diagenetic apatite, prior to being pervasively replaced by quartz and then subordinate chlorite, muscovite, and chloritoid during very low-to low-grade

metamorphism. Each new mineral replicates the soft tissues with different precision and occurs in particular anatomical regions, imposing strong biases on the biological information retained. Muscovite and chloritoid largely obliterate the tissues' original detail, suggesting that aluminum-rich protoliths may have least potential for conserving mineralized soft tissues in metamorphism. Overall, the fossils exhibit a marked shift toward mineralogical equilibration with the matrix, obscuring primary taphonomic modes. Sequential replacement of the phosphatized soft tissues released phosphorus to form new accessory monazite (and apatite and xenotime), whose presence in other BST biotas might signal the prior, more widespread, occurrence of this primary mode of preservation. Our results provide critical context for interpreting the Sirius Passet biota and for identifying late-stage overprints in other biotas.

2-28 Geology; Oceanography

Morphodynamic evolution of paraglacial spit complexes on a tide-influenced Arctic fjord delta (Dicksonfjorden, Svalbard)

Kim, Dohyeong., Jo, Joohee., **Nam, Seung-II.** and Choi, Kyungsik.

Marine Geology. 2022. 447.

doi: 10.1016/j.margeo.2022.106800

Recent global warming triggered pronounced geomorphic changes such as coastal retreat and delta progradation along the coastlines of the Arctic regions. Coastal morphodynamics and associated sediment transport at the Arctic fjord head remain relatively unexplored due to the logistically limited accessibility to the field area, especially at short-term temporal scales. A repeat survey using an unmanned aerial vehicle (UAV)-assisted photogrammetry was conducted to quantify the annual morphodynamics of gravel spit complexes developed on the tidal delta plain of the deglaciated Dicksonfjorden, Svalbard of Arctic. Results show that the spit morphodynamics varies in time and space with an overall downfjord increase in the growth and migration rate of the spits. The youngest spits elongated 22 m yr^{-1} and migrated landward 4.3 m yr^{-1} between 2015 and 2019, marking the most pronounced spit morphodynamics documented to date in the Svalbard fjord systems. The spit morphodynamics is driven primarily by longshore

drift and to a lesser degree by overwash processes. Gravels constituting the spits originate from the unconsolidated debris-flow deposits of old alluvial fans, which locally retreat 0.5 m yr^{-1} . The growth of the spit complexes is also fed by snow meltwater discharge on the alluvial fans, accounting for a downfjord imbrication of angular gravel layers that are intercalated with interlaminated sands and muds on the landward sides of the spits. The breached spits at the most upfjord location have remained stationary during the study period and presumably since the 1930s. Rapid delta progradation combined with an isostatic rebound after the Little Ice Age (LIA) has decreased spit morphodynamics on the tidal delta plain upfjord in Dicksonfjorden with infrequent and insignificant wave influence. Sparse distribution of the isolated spits signifies the intermittent spit development, which is constrained by the proximity to the protruded alluvial fans. The spit complexes in Dicksonfjorden highlight that climate change accelerates coastal geomorphic changes at the fjord head by enhancing wave intensity and regulating episodic sediment delivery that led to the downfjord shift in the locus of wave shoaling.

keywords: Spit; Tidal flat; Fjord; Morphodynamics; Climate change; Coastal erosion

2-29 Paleontology

A new titanopteran *Magnatitan jongheoni* n. gen. n. sp. from southwestern Korean Peninsula

Park, Tae-Yoon., Kim, Do-Yoon., Nam, Gi-Soo. and Lee, Mirinae.

Journal of Paleontology. 2022. 96(5): 1111-1118.

doi: 10.1017/jpa.2022.30

Titanopterans are spectacular, giant, predatory insects mainly known from the Triassic, but they are known from a few localities in Central Asia (including European Russia) and Australia. The Nampo Group is a nonmarine sequence, located on the southwestern Korean Peninsula, the age of which has remained controversial, due to lack of proper age-constraining fossils. Here, we report a new titanopteran *Magnatitan jongheoni* n. gen. n. sp. from the Amisan Formation, Nampo Group. The division of the radius anterior and radius posterior beyond the distal half of the fossil wing is a characteristic of the family Paratitanidae. This is the

first discovery of a titanopteran fossil outside of Central Asia and Australia, suggesting a possible circum-Tethys oceanic distribution. Given the possibly widespread distribution of titanopterans, this group might have played a critical role as giant predatory insects in Triassic terrestrial ecology. Because titanopterans have never been found beyond the Triassic-Jurassic boundary, the occurrence of a titanopteran corroborates the Triassic age of the Nampo Group.

2-30 Geochemistry & Geophysics

Numerical Study on the Characteristics of Abyssal T-Wave Envelopes Controlled by Earthquake Source Parameters

Yun, Sukyoung., Lee, Won Sang. and 2 others.

Seismological Research Letters. 2022. 93(4): 2189-2200.

doi: 10.1785/0220210264

Hydroacoustics has been successfully applied to detect and locate small-to-intermediate submarine tectonic activities infrequently recorded in land-based seismic arrays. However, to extend the utilization of *T* waves to extract other important earthquake source parameters, such as source strength, the roles of earthquake focal mechanisms, and source depths in *T*-wave envelopes must be thoroughly understood. We performed 3D numerical modeling considering anisotropic source radiation and realistic scattering in the oceanic crust for two focal mechanisms (normal and strike-slip faults) and three depths (5, 10, and 15 km) to investigate the effect of source radiation and focal depth on abyssal *T* waves. By analyzing the synthetic *T*-wave envelopes, we showed that stronger *SV*-energy radiation from a normal-fault earthquake event generates higher-intensity *T* waves of the same source magnitude. The anisotropic source radiation of a double-couple source causes azimuthal changes in the shapes of *T* waves, and deeper earthquakes cause gentle-sloped envelopes; however, the slopes also vary with respect to the azimuths of receivers and focal mechanisms. Temporal changes in the slopes of *T*-wave envelopes of magmatic swarm events near Wordie Volcano, Bransfield Strait, Antarctic Peninsula, imply that the depth dependency can be utilized to determine relative depths for hydrothermal-vent events or sequenced earthquakes.

2-31

Occurrence of Pyrobitumen in the Lower Cretaceous Jinju Formation, Korea

Choi, Taejin., Lim, Hyoun-Soo., **Lee, Jae-Il.** and Lee, Yong-Il.

The Journal of The Korean Earth Science Society. 2022. 43(5): 639-646

doi: 10.5467/JKESS.2022.43.5.639

Occurrence of black opaque hydrocarbon (pyrobitumen) in some Cretaceous Jinju sandstones of the Sindong Group, Gyeongsang Basin in Korea is first reported in this study. The pyrobitumen is developed on chlorite pore-lining cement, or impregnated into the outer zone of chlorite cement. Therefore, it seems to have been formed after the precipitation of chlorite cement, indicating the former presence of crude oil. The liquid hydrocarbons migrated into sandstones during moderate burial and these sandstones seem to have acted as a liquid hydrocarbon reservoir. The presence of pyrobitumen in the Jinju Formation indicates that this formation underwent deep burial after liquid hydrocarbon migration. As reservoir temperatures increased further, hydrocarbons were cracked and a solid pyrobitumen residue remained in the reservoir.

keywords: hydrocarbon; pyrobitumen; Cretaceous; Jinju Formation; Korea

wuellerstorfi) foraminifera and dinocyst-based estimates of PP using the new $n = 1,968$ modern database. We constrain PP variations and export production by integrating qualitative information from bioindicators with dinocyst-based quantitative reconstructions such as PP and seasonal sea surface temperature and information about remineralization from the benthic $\Delta\delta^{13}\text{C}$ (difference between epibenthic and endobenthic foraminiferal $\delta^{13}\text{C}$ signatures). This study also includes new information on alkenone-based SST and total organic carbon which provides insights into the relationship between past regional hydrological activity and PP regime change. We show that PP, carbon export, and remineralization were generally high in the NE subtropical Atlantic Ocean during the last glacial period and that the Last Glacial Maximum (LGM) had lower $\Delta\delta^{13}\text{C}$ than the Heinrich Stadials with sustained high PP, likely allowing enhanced carbon sequestration. We link these PP periods to the dynamics of upwelling, active almost year-round during stadials, but restricted to spring-summer during interstadials and LGM, like today. During interstadials, nutrient advection through freshwater inputs during autumn-winter needs also to be considered to fully understand PP regimes.

keywords: dinocysts; stable isotopes; alkenones; last glacial maximum; Heinrich Stadials; primary productivity; remineralization

2-32 *Geology; Oceanography; Paleontology*

Ocean Productivity in the Gulf of Cadiz Over the Last 50 kyr

Penaud, A., Eynaud, F., Etourneau, J., Bonnin, J., de Vernal, A., Zaragosi, S., **Kim, Jung-Hyun.** and 4 others.

Paleoceanography and Paleoclimatology. 2022. 37(2).

doi: 10.1029/2021pa004316

Reconstructions of ocean primary productivity (PP) help to explain past and present biogeochemical cycles and climate changes in the oceans. We document PP variations over the last 50 kyr in a currently oligotrophic subtropical region, the Gulf of Cadiz. Data combine refined results from previous investigations on dinocyst assemblages, alkenones, and stable isotopes (^{18}O , ^{13}C) in planktonic (*Globigerina bulloides*) and endobenthic (*Uvigerina mediterranea*) foraminifera from cores MD04-2805 CQ and MD99-2339, with new isotopic measurements on epibenthic (*Cibicides pachyderma-Cibicidoides*

2-33 *Geology*

An optimal strategy for determining triple oxygen isotope ratios in natural water using a commercial cavity ring-down spectrometer

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

Geosciences Journal. 2022. 26(5): 637-647.

doi: 10.1007/s12303-022-0009-y

Triple oxygen isotope ratios have been increasingly acknowledged as useful hydrological tracers but measuring both $^{17}\text{O}/^{16}\text{O}$ and $^{18}\text{O}/^{16}\text{O}$ ratios with meaningful precision has been challenging due to the much lower natural abundance of ^{17}O than ^{16}O and even ^{18}O . In this study, in line with the advancement of laser-based techniques and their growing applications, we demonstrate how to optimize the determination of ^{17}O -excess ($\Delta^{17}\text{O} = \ln(\delta^{17}\text{O} + 1) - 0.528 \times \ln(\delta^{18}\text{O} + 1)$) in

natural water using a commercial wavelength-scanned cavity ring-down spectrometer (WS-CRDS). We particularly focus on how to decide the injection numbers of samples and standard solutions utilized for normalization of sample results to the VSMOW-SLAP reference scale. With a measurement strategy aimed at an uncertainty better than 10 per meg (1σ), the $\Delta^{17}\text{O}$ of Greenland Ice Sheet Precipitation (GISP) is determined to be 24 ± 9 per meg ($n = 104$), in agreement with previous literature values. By applying this method to Antarctic glacial ice, it is shown to be useful in detecting the seasonality of $\Delta^{17}\text{O}$ values in Antarctic precipitation. Our approach represents an underlying analytical method that provides guidelines for determining $\Delta^{17}\text{O}$ from various types of natural waters.

keywords: triple oxygen isotopes; CRDS; delta O-17; O-17-excess; Antarctica snow

2-34 Science & Technology

Oxygen isotopes of anhydrous primary minerals show kinship between asteroid Ryugu and comet 81P/Wild2

Kawasaki, Noriyuki., Nagashima, Kazuhide., Sakamoto, Naoya., Matsumoto, Toru., Bajo, Ken-Ichi., Wada, Sohei., Igami, Yohei., Miyake, Akira., Noguchi, Takaaki., Yamamoto, Daiki., Russell, Sara S., Abe, Yoshinari., Aleon, Jerome., Alexander, Conel M. O'd., Amari, Sachiko., Amelin, Yuri., Bizzarro, Martin., Bouvier, Audrey., Carlson, Richard W., Chaussidon, Marc., Choi, Byeon-Gak., Dauphas, Nicolas., Davis, Andrew M., Di Rocco, Tommaso., Fujiya, Wataru., Fukai, Ryota., Gautam, Ikshu., Haba, Makiko K., Hibiya, Yuki., Hidaka, Hiroshi., Homma, Hisashi., Hoppe, Peter., Huss, Gary R., Ichida, Kiyohiro., Iizuka, Tsuyoshi., Ireland, Trevor R., Ishikawa, Akira., Ito, Motoo., Itoh, Shoichi., Kita, Noriko T., Kitajima, Kouki., Kleine, Thorsten., Komatani, Shintaro., Krot, Alexander N., Liu, Ming-Chang., Masuda, Yuki., McKeegan, Kevin D., Morita, Mayu., Motomura, Kazuko., Moynier, Frederic., Nakai, Izumi., Nguyen, Ann., Nittler, Larry., Onose, Morihiko., Pack, Andreas., **Park, Changkun.** and 38 others.

Science Advances. 2022. 8(50).

doi: 10.1126/sciadv.ade2067

The extraterrestrial materials returned from asteroid (162173) Ryugu consist predominantly of low-temperature aqueously formed secondary minerals and are chemically and mineralogically similar to CI (Ivuna-type) carbonaceous chondrites. Here, we show that high-temperature anhydrous primary minerals in Ryugu and CI chondrites exhibit a bimodal

distribution of oxygen isotopic compositions: ^{16}O -rich (associated with refractory inclusions) and ^{16}O -poor (associated with chondrules). Both the ^{16}O -rich and ^{16}O -poor minerals probably formed in the inner solar protoplanetary disk and were subsequently transported outward. The abundance ratios of the ^{16}O -rich to ^{16}O -poor minerals in Ryugu and CI chondrites are higher than in other carbonaceous chondrite groups but are similar to that of comet 81P/Wild2, suggesting that Ryugu and CI chondrites accreted in the outer Solar System closer to the accretion region of comets.

2-35 Geochemistry & Geophysics; Mineralogy

Petrogenesis of the Yeonhwa ultrapotassic intrusions in the Yeongnam Massif-Evidence for enrichment of the Triassic continental lithospheric mantle beneath the Korean peninsula

Kim, Jihyuk., Park, Jung-Woo., **Lee, Mi Jung.** and 2 others. *Lithos*. 2022. 422.

doi: 10.1016/j.lithos.2022.106739

The Triassic period is when abundant late-orogenic magmatism occurred in the Korean peninsula, but the characteristics of the lithospheric mantle at that time beneath the Yeongnam Massif have not been well-defined because of the scarcity of mafic intrusions. We report zircon U-Pb and phlogopite $^{40}\text{Ar}/^{39}\text{Ar}$ ages, petrography, and geochemistry of the Triassic (227.6 Ma) ultrapotassic igneous rocks in the Yeonhwa I Mine (Yeonhwa Ultrapotassic Intrusions, YUI) emplaced into the Taebaeksan Basin in the Yeongnam Massif. The YUI occur as two stocks with different lithologies: phlogopite-rich and amphibole-rich, where the former underwent carbonate-melt interaction along the margin in contact with the carbonate formation. The two lithologies share similar compositional and isotopic characteristics; however, the phlogopite-rich YUI better retains its mantle-derived features, having idiomorphic high-Mg# (up to 91.9) phlogopite and diopside phenocrysts and bulk concentrations of high MgO ($\text{Mg\#} = \text{molar } 100 \text{ Mg}/[\text{Mg} + \text{Fe}] > 70$), Cr (208–1150 ppm), and Ni (48–219 ppm). The enrichment of the YUI in H_2O (phlogopite-rich), silica contents (50.2–56.9 wt%), and large ion lithophile elements (LILE; K, Rb, Sr, Ba, Pb), together with depletion of high fields strength elements (HFSE; Ti, Zr, Nb, Hf, Ta), are typical of the ultrapotassic rocks in orogenic settings. The elemental

and isotopic data imply that the YUI originated from partial melts of the phlogopite-bearing lithospheric mantle near the spinel-garnet transition zone. The extremely enriched isotopic ratios ($^{87}\text{Sr}/^{86}\text{Sr}(t) = 0.70756$ to 0.71227 , $\epsilon_{\text{Nd}}(t) = -8.82$ to -11.0) suggest a highly enriched mantle source, possibly more enriched than the contemporary pelagic sediments. Considering that the Yeongnam Massif was in a subduction system during Permian-Triassic, not a continental collisional belt, the enrichment was inherited from a combination of both young, subduction-related and ancient, pre-existing metasomes in the continental lithospheric mantle. Our data confirm the presence of the enriched, volatile-rich lithospheric mantle beneath the Triassic Yeongnam Massif. This enriched origin contrasts with earlier (c. 240–280 Ma) Yeongnam arc plutons that originated from the depleted asthenospheric mantle ($\epsilon_{\text{Nd}}(t) \geq +2$). Since the enrichment is also characteristic of most of the c. 220–240 Ma igneous rocks around the Korean peninsula, such lithospheric mantle lithology was widespread during the Late Triassic.

keywords: Triassic; Yeonhwa ultrapotassic intrusions; Yeongnam Massif; Mantle metasomatism; Lithospheric mantle

Myr with a mean sedimentation rate of 0.88 cm/kyr, providing insights into paleoceanographic variability in the Ross Sea throughout the Pleistocene. Winnowed deposits enriched in iceberg rafted debris were formed due to a combination of enhanced glacial calving during glacial retreats, and export of Dense Shelf Water during interglacial and weak glacial periods when the ice-sheet was not grounded in the outer Joides Trough. During periods where the ice sheet grounded on the outer Ross Sea continental shelf, laminated sediments rich in reworked diatoms are interpreted to have formed due to glacial scouring and transport of shelf sediments to the mouth of the Joides Trough, where slope failures and meltwater pulses remobilized this material downslope to the Central Basin. Dense shelf water formation is inferred to be most intense during interglacial periods, with reduced export from the Joides Trough during ice sheet advances. The study does not find any evidence for prolonged ice-sheet grounding in the outer Ross Sea since ~0.3 Ma, however, we conclude that the grounding line reached the outer shelf frequently between 0.3 and 1.2 Ma, supporting higher Antarctic ice volumes during glacial periods in this interval.

keywords: Ross Sea; Relative paleointensity; Diatom; Reworking; Paleoceanography; Sedimentology

2-36 *Physical Geography; Geology*

Pleistocene oceanographic variability in the Ross Sea: A multiproxy approach to age model development and paleoenvironmental analyses

Bollen, Michael., Riesselman, Christina R., Ohneiser, Christian., Albot, Olga., McKay, Robert., **Lee, Min Kyung., Yoo, Kyu-Cheul., Kim, Sunghan., Lee, Jae Il.** and Levy, Richard.

Global and Planetary Change. 2022. 216.

doi: 10.1016/j.gloplacha.2022.103901

Understanding how ocean circulation has varied around Antarctica in the past is vital because significant volumes of ice are grounded below sea level, and therefore ice sheet variations are strongly coupled with oceanographic variability at the continental shelf margin. This study investigates the 11.75 m sediment core RS15-LC42, retrieved from the Central Basin of the Ross Sea. A magneto-biostratigraphic age model was constructed from a magnetic reversal stratigraphy, diatom biostratigraphy, and the relative paleointensity of the geomagnetic field. The core spans the last 1.34

2-37 *Astronomy & Astrophysics*

Presolar Stardust in Asteroid Ryugu

Barosch, Jens., Nittler, Larry R., Wang, Jianhua., Alexander, Conel M. O'D., De Gregorio, Bradley T., Engrand, Cecile., Kebukawa, Yoko., Nagashima, Kazuhide., Stroud, Rhonda M., Yabuta, Hikaru., Abe, Yoshinari., Aleon, Jerome., Amari, Sachiko., Amelin, Yuri., Bajo, Ken-ichi., Bejach, Laure., Bizzarro, Martin., Bonal, Lydie., Bouvier, Audrey., Carlson, Richard W., Chaussidon, Marc., Choi, Byeon-Gak., Cody, George D., Dartois, Emmanuel., Dauphas, Nicolas., Davis, Andrew M., Dazzi, Alexandre., Deniset-Besseau, Ariane., Di Rocco, Tommaso., Duprat, Jean., Fujiya, Wataru., Fukai, Ryota., Gautam, Ikshu., Haba, Makiko K., Hashiguchi, Minako., Hibiya, Yuki., Hidaka, Hiroshi., Homma, Hisashi., Hoppe, Peter., Huss, Gary R., Ichida, Kiyohiro., Iizuka, Tsuyoshi., Ireland, Trevor R., Ishikawa, Akira., Ito, Motoo., Itoh, Shoichi., Kamide, Kanami., Kawasaki, Noriyuki., Kilcoyne, A. L. David., Kita, Noriko T., Kitajima, Kouki., Kleine, Thorsten., Komatani, Shintaro., Komatsu, Mutsumi., Krot, Alexander N., Liu, Ming-Chang., Martins, Zita., Masuda, Yuki., Mathurin, Jeremie., McKeegan, Kevin D., Montagnac, Gilles., Morita, Mayu., Mostefaoui, Smail., Motomura, Kazuko., Moynier, Frederic., Nakai, Izumi., Nguyen, Ann N., Ohigashi, Takuji., Okumura, Taiga., Onose, Morihiko., Pack,

Andreas., **Park, Changkun.** and 52 others.
Astrophysical Journal Letters. 2022. 935(1).
doi: 10.3847/2041-8213/ac83bd

We have conducted a NanoSIMS-based search for presolar material in samples recently returned from C-type asteroid Ryugu as part of JAXA's Hayabusa2 mission. We report the detection of all major presolar grain types with O- and C-anomalous isotopic compositions typically identified in carbonaceous chondrite meteorites: 1 silicate, 1 oxide, 1 O-anomalous supernova grain of ambiguous phase, 38 SiC, and 16 carbonaceous grains. At least two of the carbonaceous grains are presolar graphites, whereas several grains with moderate C isotopic anomalies are probably organics. The presolar silicate was located in a clast with a less altered lithology than the typical extensively aqueously altered Ryugu matrix. The matrix-normalized presolar grain abundances in Ryugu are $4.8^{+4.7}_{-2.6}$ ppm for O-anomalous grains, 25^{+6}_{-5} ppm for SiC grains, and 11^{+5}_{-3} ppm for carbonaceous grains. Ryugu is isotopically and petrologically similar to carbonaceous Ivuna-type (CI) chondrites. To compare the in situ presolar grain abundances of Ryugu with CI chondrites, we also mapped Ivuna and Orgueil samples and found a total of 15 SiC grains and 6 carbonaceous grains. No O-anomalous grains were detected. The matrix-normalized presolar grain abundances in the CI chondrites are similar to those in Ryugu: 23^{+7}_{-6} ppm SiC and $9.0^{+5.4}_{-3.6}$ ppm carbonaceous grains. Thus, our results provide further evidence in support of the Ryugu–CI connection. They also reveal intriguing hints of small-scale heterogeneities in the Ryugu samples, such as locally distinct degrees of alteration that allowed the preservation of delicate presolar material.

2-38 *Physical Geography; Geology*

Quaternary ice thinning of David Glacier in the Terra Nova Bay region, Antarctica

Rhee, Hyun Hee., Lee, Min Kyung., Seong, Yeong Bae., **Lee, Jae Il., Yoo, Kyu-Cheul.** and 2 others.

Quaternary Geochronology. 2022. 67.

doi: 10.1016/j.quageo.2021.101233

Understanding the history of Antarctic glaciation is important for interpreting paleoclimatic changes and estimating the changes in climate, sea level, and ice

volume in the future. Ice core studies of the East Antarctic Ice Sheet (EAIS) and marine sediment cores from the entire Ross Sea have employed numerous proxies to reconstruct the glacial history of the Antarctic region. However, the ice and marine core records can be biased because of their specific locations, such as the uppermost accumulation zone or the terminus of the ablation zone, thereby introducing significant uncertainties in ice modeling. In this study, we analyzed 34 new ^{10}Be and ^{26}Al samples from four benches that were glaciated in the past by David glacier and incorporate the present ice-free flat surfaces. We suggest that the David glacier experienced monotonic and stepwise vertical lowering along the flanks of Mt. Priestley since the early Pleistocene. The uppermost bedrock benches on Mt. Priestley were exposed at 1.77 ± 0.32 Ma, with no evidence of subsequent overriding by readvancing ice. At Mt. Priestley, the David glacier has been characterized by a cold-based regime since 1.77 Ma, with a denudation rate of only ~ 16 cm/Ma, corresponding to the regional transition from warm to cold-based glaciation at 3.5 Ma. Simple exposure ages from two lower benches date to Marine Isotope Stage (MIS) 7 (234.1 ± 13.1 ka; 545 m asl) and MIS 4 (64.8 ± 13.7 ka; 222 m asl), suggesting that, since MIS 8, the overall lowering of glaciers has remained monotonic. The upper bench marks the lower limit of the MIS 8 glacial period and the upper limit of Penultimate Glacial Maximum (MIS 6), while the lower landform defines the upper limit of the last glacial period (MIS 4–2). The magnitude of Quaternary ice thinning at the David glacier was the highest (~ 990 m) in the present terminal area (i.e., the most sensitive ablation zone), in contrast to the other outlet glaciers draining into the Terra Nova Bay, which experienced less ice lowering. The combination of the terrestrial (in situ ^{10}Be and ^{26}Al) and previous marine (authigenic ^{10}Be) cosmogenic data used in our study document the history of lowering of the David glacier driven by climatic changes during the Pleistocene. Both deglaciation and glaciation were limited during the mid-Pleistocene transition (MPT) and prior to the mid-Bruhnes event (MBE), due to the prevailing cold and arid climate, whereas deglaciation was dominant during other warm periods.

keywords: Victoria land; Antarctica; Cosmogenic nuclides; Deglaciation; Mid-bruhnes event; Quaternary; Ross sea

2-39 *Science & Technology***Rapid seafloor changes associated with the degradation of Arctic submarine permafrost**

Paull, Charles K., Dallimore, Scott R., **Jin, Young Keun.** and 7 others.

Proceedings of the National Academy of Sciences of the United States of America. 2022. 119(12).

doi: 10.1073/pnas.2119105119

Repeated high-resolution bathymetric surveys of the shelf edge of the Canadian Beaufort Sea during 2- to 9-y-long survey intervals reveal rapid morphological changes. New steep-sided depressions up to 28 m in depth developed, and lateral retreat along scarp faces occurred at multiple sites. These morphological changes appeared between 120-m and 150-m water depth, near the maximum limit of the submerged glacial-age permafrost, and are attributed to permafrost thawing where ascending groundwater is concentrated along the relict permafrost boundary. The groundwater is produced by the regional thawing of the permafrost base due to the shift in the geothermal gradient as a result of the interglacial transgression of the shelf. In contrast, where groundwater discharge is reduced, sediments freeze at the ambient sea bottom temperature of ~ -1.4 °C. The consequent expansion of freezing sediment creates ice-cored topographic highs or pingos, which are particularly abundant adjacent to the discharge area.

keywords: permafrost; Arctic; repeat mapping; pingos; thermokarst

the glacial landforms using in-situ cosmogenic-nuclide ^{10}Be surface exposure dating to reconstruct the paleo-glacial dynamics. The surface of the Hollingsworth glacier lowered since the middle of Marine Isotope Stage (MIS) 2 (22.1 ka); therefore, the Last Glacial Maximum (LGM) occurred before that period. Cosmogenic, geomorphic, and climatic records constrained the glacial surface slope to be between 5.4° and 6.8°. The ice was 270–320 m thicker at the LGM (MIS 2) than presently but did not override the top surface of the Benson Knob. Moreover, previous glacial periods such as the local LGM (MIS 4) or Penultimate Glacial Maximum (MIS 6) maintained thicker ice than the LGM (MIS 2). The Ross Ice Shelf opening during the mid-Holocene (~ 6 ka) caused the rapid collapse of the terminal outlet glaciers and supplied notable snow accumulation upstream, which stagnated lowering. The greatest lowering and retreat occurred during the late Holocene (2.3 $\sim$ 0.8 ka), when elephant seal colonies thrived in the Ross Embayment.

keywords: East Antarctic Ice Sheet; Last Glacial Maximum; Deglaciation; Holocene; Cosmogenic nuclide exposure dating; Glacier reconstruction

2-41 *Geochemistry & Geophysics***A record of low-temperature asteroidal processes of amoeboid olivine aggregates from the Kainsaz CO3.2 chondrite**

Han, Jangmi., **Park, Changkun.** and Brearley, Adrian J.

Geochimica Et Cosmochimica Acta. 2022. 322: 109-128.

doi: 10.1016/j.gca.2022.02.007

Amoeboid olivine aggregates (AOAs) from the Kainsaz CO3.2 chondrite were analyzed using transmission electron microscopy in order to gain a more complete understanding of thermal metamorphism on the parent body and the role of fluids during metamorphic heating. The Kainsaz AOAs are dominated by strongly zoned, fine-grained, olivine grains (Fa_{2-31}) with heterogeneous Fe enrichments along the grain boundaries, which are interpreted as the result of Fe^{2+} - Mg^{2+} interdiffusion with the matrix during thermal metamorphism. However, our diffusion calculations show that such AOA olivine zoning and compositions cannot be produced by a simple diffusional exchange during metamorphic heating, unlike chondrule olivine zoning and compositions. In addition, fine-grained ferroan olivine overgrowths

2-40 *Environmental Sciences & Ecology***Reconstructing the post-LGM deglacial history of Hollingsworth Glacier on Ricker Hills, Transantarctic Mountains, Antarctica**

Rhee, Hyun-Hee., Seong, Yeong-Bae., Woo, Ju-Sun., Oh, Changhwan. and Yu, Byung-Yong.

Journal of Mountain Science. 2022. 19(5): 1217-1230.

doi: 10.1007/s11629-022-7338-1

The Transantarctic Mountains are an important corridor between the East Antarctic Ice Sheet and the Western Ross Sea, where most current ice streams and outlet glaciers arise. We investigated Ricker Hills, the largest exposed mountainous region between Southern Victoria Land and Terra Nova Bay, and dated

occur heterogeneously in crystallographic continuity with olivines on the AOA exteriors. The overgrowths (Fa₃₃₋₃₆) are compositionally distinct from the underlying AOA olivines and are not fully equilibrated with the matrix olivines (Fa_{~20-55}). The ferroan olivine overgrowths likely formed by precipitation from fluids in an epitaxial relationship with forsteritic olivine on the edges of AOAs. Texturally and compositionally diverse chromite grains are also observed along olivine grain boundaries, in olivine grains, and in pore spaces between olivine grains. They share a similar crystallographic orientation relationship with adjacent olivine, suggestive of their formation by exsolution and/or epitaxial growth. Collectively, these observations provide evidence for the mobilization of Fe, Mg, Si, Cr, and Al in the presence of fluids along olivine grain boundaries and into olivine grains during thermal metamorphism. We conclude that in Kainsaz AOAs, the strong zonation development in individual olivine grains and the formation of ferroan olivine overgrowths and chromite grains were a fluid-driven process that occurred at relatively low temperatures (<500 °C), during the cooling history of the CO₃ chondrite parent body, following the peak of thermal metamorphism.

keywords: Amoeboid olivine aggregates; Transmission electron microscopy; Thermal metamorphism; Fluid; CO₃ chondrites

megalamellatum Jeon n. sp., *Clathrodictyon plicatum* Webby and Banks, 1976, *Ecclimadictyon nestori* Webby, 1969, *Ecclimadictyon undatum* Webby and Banks, 1976, *Camptodictyon amzassensis* (Khalfina, 1960), and *Labyrinthodictyon cascum* (Webby and Morris, 1976). The clathrodictyid fauna in the Xiazhen Formation is very similar to those from both New South Wales and Tasmania, although the latter two Australian regions do not share any common clathrodictyid species during the Late Ordovician. The paleobiogeographic pattern indicates that the northward drift of South China resulted in a favorable environment for the migration of clathrodictyids from other peri-Gondwanan terranes to South China. In addition, these peri-Gondwanan clathrodictyid species hosted various endobionts, representing a variety of paleoecological interactions. The high abundance and species-level diversity of clathrodictyid species presumably increased the substrate availability of suitable host taxa, judging from the diverse intergrowth associations between clathrodictyids and other benthic organisms. These paleoecological interactions between stromatoporoid and other organisms are known from the Late Ordovician and became more abundant and widespread in the Siluro–Devonian. Overall, the Late Ordovician clathrodictyid assemblage in South China demonstrates one of the highest species-level diversities among all peri-Gondwanan terranes and represents a precursor of the complex, clathrodictyid-dominated communities of later metazoan reefs during the Great Ordovician Biodiversification Event.

2-42 Paleontology

Rise of clathrodictyid stromatoporoids during the Great Ordovician Biodiversification Event: insights from the Upper Ordovician Xiazhen Formation of South China

Jeon, Juwan., Liang, Kun., Kershaw, Stephen., Park, Jino., Lee, Mirinae. and Zhang, Yuandong.

Journal of Paleontology. 2022. 96(6): 1483-1483.

doi: 10.1017/jpa.2022.69

Clathrodictyids are the most abundant stromatoporoids in the Upper Ordovician Xiazhen Formation (middle to upper Katian) of South China. A total of nine species belonging to four clathrodictyid genera are identified in the formation, including *Clathrodictyon idense* Webby and Banks, 1976, *Clathrodictyon cf. Cl. microundulatum* Nestor, 1964, *Clathrodictyon cf. Cl. mammillatum* (Schmidt, 1858), *Clathrodictyon*

2-43 Science & Technology

Ryugu's nucleosynthetic heritage from the outskirts of the Solar System

Hopp, Timo., Dauphas, Nicolas., 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., Davis, Andrew M., Di Rocco, Tommaso., Fujiya, Wataru., Fukai, Ryota., Gautam, Ikshu., Haba, Makiko K., Hibiya, Yuki., Hidaka, Hiroshi., Homma, Hisashi., Hoppe, Peter., Huss, Gary R., Ichida, Kiyohiro., Iizuka, Tsuyoshi., Ireland, Trevor R., Ishikawa, Akira., Ito, Motoo., Itoh, Shoichi., Kawasaki, Noriyuki., Kita, Noriko T., Kitajima, Kouki., Kleine, Thorsten., Komatani, Shintaro., Krot, Alexander N., Liu, Ming-Chang., Masuda, Yuki., McKeegan, Kevin D., Morita, Mayu., Motomura, Kazuko., Moynier, Frederic., Nakai, Izumi., Nagashima, Kazuhide., Nesvorny, David., Nguyen, Ann., Nittler, Larry., Onose, Morihiko.,

Pack, Andreas., **Park, Changkun.** and 42 others.

Science Advances. 2022. 8(46).

doi: 10.1126/sciadv.add8141

Little is known about the origin of the spectral diversity of asteroids and what it says about conditions in the protoplanetary disk. Here, we show that samples returned from Cb-type asteroid Ryugu have Fe isotopic anomalies indistinguishable from Ivuna-type (CI) chondrites, which are distinct from all other carbonaceous chondrites. Iron isotopes, therefore, demonstrate that Ryugu and CI chondrites formed in a reservoir that was different from the source regions of other carbonaceous asteroids. Growth and migration of the giant planets destabilized nearby planetesimals and ejected some inward to be implanted into the Main Belt. In this framework, most carbonaceous chondrites may have originated from regions around the birthplaces of Jupiter and Saturn, while the distinct isotopic composition of CI chondrites and Ryugu may reflect their formation further away in the disk, owing their presence in the inner Solar System to excitation by Uranus and Neptune.

underlying *LgEstl* activity and subject it to protein engineering, we determined the high-resolution crystal structure of *LgEstl*. First, the wild-type *LgEstl* protein was crystallized in 0.1 M Tris-HCl buffer (pH 7.1), 0.2 M calcium acetate hydrate, and 19% (w/v) PEG 3000, and the native X-ray diffraction dataset was collected up to 2.0 Å resolution. The crystal structure was successfully determined using a molecular replacement method, and structure refinement and model building are underway. The upcoming complete structural information of *LgEstl* may elucidate the substrate-binding mechanism and provide novel strategies for subjecting *LgEstl* to protein engineering.

keywords: esterase; *Lactococcus garvieae*; X-ray crystallography

2-44 Crystallography; Materials Science

Sequence Analysis and Preliminary X-ray Crystallographic Analysis of an Acetylsterase (*LgEstl*) from *Lactococcus garvieae*

Do, Hackwon., Wang, Ying., **Lee, Chang Woo.**, Yoo, Wanki., Jeon, Sangeun., **Hwang, Jisub.**, **Lee, Min Ju.**, Kim, Kyeong Kyu, **Kim, Han-Woo.**, **Lee, Jun Hyuck.** and Kim, T. Doohun.

Crystals. 2022. 12(1).

A gene encoding *LgEstl* was cloned from a bacterial fish pathogen, *Lactococcus garvieae*. Sequence and bioinformatic analysis revealed that *LgEstl* is close to the acetyl esterase family and had maximum similarity to a hydrolase (UniProt: Q5UQ83) from *Acanthamoeba polyphaga mimivirus* (APMV). Here, we present the results of *LgEstl* overexpression and purification, and its preliminary X-ray crystallographic analysis. The wild-type *LgEstl* protein was overexpressed in *Escherichia coli*, and its enzymatic activity was tested using *p*-nitrophenyl of varying lengths. *LgEstl* protein exhibited higher esterase activity toward *p*-nitrophenyl acetate. To better understand the mechanism

2-45 Geochemistry & Geophysics

The Solar System calcium isotopic composition inferred from Ryugu samples

Moynier, F., Dai, W., Yokoyama, T., Hu, Y., Paquet, M., Abe, Y., Aleon, J., Alexander, C. M. O'D, Amari, S., Amelin, Y., Bajo, K. I., Bizzarro, M., Bouvier, A., Carlson, R. W., Chaussidon, M., Choi, B. G., Dauphas, N., Davis, A. M., Di Rocco, T., Fujiya, W., Fukai, R., Gautam, I., Haba, M. K., Hibiya, Y., Hidaka, H., Homma, H., Hoppe, P., Huss, G. R., Ichida, K., Iizuka, T., Ireland, T. R., Ishikawa, A., Ito, M., Itoh, S., Kawasaki, N., Kita, N. T., Kitajima, K., Kleine, T., Komatani, S., Krot, A. N., Liu, M. C., Masuda, Y., McKeegan, K. D., Morita, M., Motomura, K., Nakai, I., Nagashima, K., Nesvorný, D., Nguyen, A., Nittler, L., Onose, M., Pack, A., **Park, Changkun.** and 41 others.

Geochemical Perspectives Letters. 2022. 24.

doi: 10.7185/geochemlet.2238

The Hayabusa2 spacecraft has returned samples from the Cb-type asteroid (162173) Ryugu to Earth. Previous petrological and chemical analyses support a close link between Ryugu and CI chondrites that are presumed to be chemically the most primitive meteorites with a solar-like composition. However, Ryugu samples are highly enriched in Ca compared to typical CI chondrites. To identify the cause of this discrepancy, here we report stable Ca isotopic data (expressed as $\delta^{44/40}\text{Ca}_{\text{SRM915a}}$) for returned Ryugu samples collected from two sites. We found that samples from both sites have similar $\delta^{44/40}\text{Ca}_{\text{SRM915a}}$ ($0.58 \pm 0.03 \text{ ‰}$ and $0.55 \pm 0.08 \text{ ‰}$, 2 s.d.) that fall within the range defined by CIs. This isotopic similarity suggests that the Ca budget of CIs and Ryugu samples is dominated by carbonates, and the variably

higher Ca contents in Ryugu samples are due to the abundant carbonates. Precipitation of carbonates on Ryugu likely coincided with a major episode of aqueous activity dated to have occurred ~5 Myr after Solar System formation. Based on the pristine Ryugu samples, the average $\delta^{44/40}\text{Ca}_{\text{SRM915a}}$ of the Solar System is defined to be $0.57 \pm 0.04 \text{ ‰}$ (2 s.d.).

keywords: asteroid, solar system, calcium, isotopes, Ryugu, Hayabusa2, alteration, carbonates

2-46 *Geology*

Spatial variations of authigenic beryllium isotopes in surface sediments of the Antarctic oceans: a proxy for sea ice dynamics and sedimentary environments

Rhee, Hyun Hee., Seong, Yeong Bae., Lee, Min Kyung., Jeong, Ara., Dash, Chinmay., Lee, Jae Il., Yoo, Kyu-Cheul. and Yu, Byung Yong.

Geosciences Journal. 2022. 26(4): 455-467.

doi: 10.1007/s12303-022-0003-4

This study documents spatial variations in authigenic ^9Be and ^{10}Be concentrations and $^{10}\text{Be}/^9\text{Be}$ ratios in different glacial settings in the Weddell and Ross seas, Antarctica. Weddell Sea surface sediments have the lowest ^{10}Be and highest ^9Be concentrations, and most depleted $^{10}\text{Be}/^9\text{Be}$ ratios, as compared with other regions, indicating ^9Be enrichment from the recently collapsed Larsen Ice Shelf (LIS) B and reduction of ^{10}Be supply due to blockage by the un-deglaciated LIS C. Local ^{10}Be deposition varies across the open marine Ross Sea, which is more affected by seasonal sea ice persistence than ocean currents. Higher $^{10}\text{Be}/^9\text{Be}$ ratios in the western Ross Sea and higher ^{10}Be concentrations in the eastern Ross Sea correlate with higher sea ice concentrations and changes, and vice versa in the central Ross Sea. The higher sea ice concentration not only blocks atmospheric ^{10}Be and dust deposition during the frozen season, but increases the dust flux and supply of Be isotopes during the sea ice melting season. Thus, the spatial distribution of Be isotopes in surface sediments of the Antarctic oceans can be used as a proxy for sea ice dynamics and sedimentary environments.

keywords: Antarctica; cosmogenic ^{10}Be ; sea ice; oceanic sedimentation; local contamination offset

2-47 *Agriculture*

Statistical understanding for snow cover effects on near-surface ground temperature at the margin of maritime Antarctica, King George Island

Lim, Hyoun Soo., Kim, Hyun-Cheol., Kim, Ok-Sun., Jung, Hyejung., Lee, Jeonghoon. and Hong, Soon Gyu.

Geoderma. 2022. 410.

doi: 10.1016/j.geoderma.2021.115661

Snow cover plays an important role in water supply through melting of snow/ice in polar ecosystem and environments, in particular, Antarctica. Although a site access to Antarctica is high-priced, measurements of ground surface temperature (GST) using small self-recording temperature sensors (iButtons) can provide a powerful and relatively inexpensive approach to trace the spatial and temporal distributions of soil temperature and in addition, absence/presence of snow cover. In this study, principal component analysis (PCA) was utilized to explain major patterns of GST from 128 sites at King George Island in maritime Antarctica. Variations of GST were monitored between December 2011 and January 2013. The iButtons were initially installed in snow free areas in the austral summer of 2011. Principal components 1 and 2 were associated with air temperature and snow cover, respectively. Both PCs showed good correlations with the mean GST of JJA (June to August), not with that of DJF (December to January). Based on the results excluding an outlier, PCA divided the 127 GST observations into three groups effectively: absence of snow cover (Group 1), intermittent snow cover (Group 2), and presence of snow cover (Group 3). Snow cover can supply water to the ecosystem and the GST pattern of Group 2 may imply an abundance and high productivity of mosses in the study area. Using approaches suggested by previous studies, snow cover showed up nine days (days 317–326), and the melt-out date was day 326 (KG125 in Group 2). The GST data and statistical approaches used in this study can be useful in other GST studies, particularly, for both polar regions

keywords: Ground surface temperature; King George Island; Principal component analysis; Snow cover

2-48 *Geochemistry & Geophysics; Engineering; Remote Sensing; Imaging Science & Photographic Technology*

Thermal Denoising of Cross-Polarized Sentinel-1 Data in Interferometric and Extra Wide Swath Modes

Korosov, Anton., Demchev, Denis., Miranda, Nuno., Franceschi, Niccolo. and **Park, Jeong-Won.**

Ieee Transactions on Geoscience and Remote Sensing. 2022. 60.

doi: 10.1109/tgrs.2021.3131036

An updated algorithm for the removal of thermal noise in Sentinel-1 synthetic aperture radar (SAR) level-1 ground range detected (GRD) data in cross-polarization is presented. The algorithm is comprised of two steps: correction of the annotated thermal noise magnitude (previously proposed in Park et al. , 2018) and a novel correction of the annotated thermal noise range dependence. The magnitude of the annotated thermal noise is corrected by applying scale and offset coefficients tuned on a few hundred of Sentinel-1 data acquired over surfaces with low backscatter in interferometric wide and extra-wide swath modes in HV and VH polarizations. The values of coefficients for all modes and polarizations for data processing with the Instrument Processing Facility (IPF) version 3.1–3.3 are provided. The range dependence is corrected by minimizing a cost function between the annotated range profiles of thermal noise and antenna pattern gain (APG). An objective validation metric based on a comparison of averaged backscatter at interswath boundaries is proposed. Validation is performed on hundreds of Sentinel-1 scenes acquired over the open ocean, doldrums, deserts, and sea ice. It shows that the new algorithm outperforms the standard thermal noise removal algorithm proposed by European Space Agency in almost all cases. Analysis shows that the new algorithm worsens noise correction in cases when the range dependence of the annotated APG does not match with the observed signal, indicating either problems with signal processing on IPF or imprecise annotation of APG.

keywords: Thermal noise; Synthetic aperture radar; Sea ice; Training; Table lookup; Sea surface; Ocean temperature; Remote sensing; synthetic aperture radar (SAR); Terrain Observation with Progressive Scans SAR (TOPSAR); thermal noise

2-49 *Geology*

Tidal Modulation of a Lateral Shear Margin: Priestley Glacier, Antarctica

Still, Holly., Hulbe, Christina., Forbes, Martin., Prior, David J., Bowman, M. Hamish., Boucinhas, Bia., Craw, Lisa., **Kim, Daeyeong.** and 3 others.

Frontiers in Earth Science. 2022. 10.

doi: 10.3389/feart.2022.828313

We use high resolution, ground-based observations of ice displacement to investigate ice deformation across the floating left-lateral shear margin of Priestley Glacier, Terra Nova Bay, Antarctica. Bare ice conditions allow us to fix survey marks directly to the glacier surface. A combination of continuous positioning of a local reference mark, and repeat positioning of a network of 33 stakes installed across a 2 km width of the shear margin are used to quantify shear strain rates and the ice response to tidal forcing over an 18-day period. Along-flow velocity observed at a continuous Global Navigation Satellite Systems (GNSS) station within the network varies by up to ~30% of the mean speed ($\pm 28 \text{ m a}^{-1}$) over diurnal tidal cycles, with faster flow during the falling tide and slower flow during the rising tide. Long-term deformation in the margin approximates simple shear with a small component of flow-parallel shortening. At shorter timescales, precise optical techniques allow high-resolution observations of across-flow bending in response to the ocean tide, including across-flow strains on the order of 10^{-5} . An elastodynamic model informed by the field observations is used to simulate the across-flow motion and deformation. Flexure is concentrated in the shear margin, such that a non-homogeneous elastic modulus is implied to best account for the combined observations. The combined pattern of ice displacement and ice strain also depends on the extent of coupling between the ice and valley sidewall. These conclusions suggest that investigations of elastic properties made using vertical ice motion, but neglecting horizontal displacement and surface strain, will lead to incorrect conclusions about the elastic properties of ice and potentially over-simplified assumptions about the sidewall boundary condition.

keywords: shear margin; tides; ice deformation; elastic model; ice flexure; GNSS; Priestley Glacier; Antarctica

Ultrasonic and seismic constraints on crystallographic preferred orientations of the Priestley Glacier shear margin, Antarctica

Lutz, Franz., Prior, David J., Still, Holly., Bowman, M. Hamish., Boucinhas, Bia., Craw, Lisa., Fan, Sheng., **Kim, Daeyeong.** and 3 others.

Cryosphere. 2022. 16(8): 3313-3329.

doi: 10.5194/tc-16-3313-2022

Crystallographic preferred orientations (CPOs) are particularly important in controlling the mechanical properties of glacial shear margins. Logistical and safety considerations often make direct sampling of shear margins difficult, and geophysical measurements are commonly used to constrain the CPOs. We present here the first direct comparison of seismic and ultrasonic data with measured CPOs in a polar shear margin. The measured CPO from ice samples from a 58 m deep borehole in the left lateral shear margin of the Priestley Glacier, Antarctica, is dominated by horizontal c axes aligned sub-perpendicularly to flow. A vertical-seismic-profile experiment with hammer shots up to 50 m away from the borehole, in four different azimuthal directions, shows velocity anisotropy of both P waves and S waves. Matching P-wave data to the anisotropy corresponding to CPO models defined by horizontally aligned c axes gives two possible solutions for the c-axis azimuth, one of which matches the c-axis measurements. If both P-wave and S-wave data are used, there is one best fit for the azimuth and intensity of c-axis alignment that matches the measurements well. Azimuthal P-wave and S-wave ultrasonic data recorded in the laboratory on the ice core show clear anisotropy of P-wave and S-wave velocities in the horizontal plane that match that predicted from the CPO of the samples. With quality data, azimuthal increments of 30° or less will constrain well the orientation and intensity of c-axis alignment. Our experiments provide a good framework for planning seismic surveys aimed at constraining the anisotropy of shear margins.

Unique igneous textures and shock metamorphism of the Northwest Africa 7203 angrite: Implications for crystallization processes and the evolutionary history of the angrite parent body

Hayashi, Hideyuki., Mikouchi, Takashi., **Kim, Nak Kyu., Park, Changkun.** and 5 others.

Meteoritics & Planetary Science. 2022. 57(1): 105-121.

doi: 10.1111/maps.13776

Northwest Africa (NWA) 7203 is a quenched angrite, showing mineralogical features typically not present in other quenched angrites. NWA 7203 exhibits textures whose grain size varies from fine grains (<10 µm) to coarse grains (~3 mm), while other quenched angrites show only single-sized textures. Fine-grained and coarse-grained lithologies have nearly the same bulk compositions. Cooling rates were estimated to be ~80 °C h⁻¹ for fine-grained lithologies and ~1 °C h⁻¹ for coarse-grained lithologies. Mg-rich olivines (~Fo₆₄) were found only in fine-grained lithologies. Crystallization of NWA 7203 started in the fine-grained lithologies with Mg-rich olivine grains acting as seeds for crystallization. Coarse-grained lithologies were subsequently formed under conditions of slower cooling. NWA 7203 shows clear shock metamorphic textures unlike other quenched angrites except for NWA 1670. We confirm that the oxygen isotopic ratios of NWA 7203 plot on the angrite fractionation line within uncertainty. However, the obtained Pb-Pb age of NWA 7203 is 4543 ± 19 Ma, younger than the ages of other quenched angrites, which might be a result of disturbance by shock metamorphism. The finding of shock metamorphism of NWA 7203 suggests that some angrites might be derived from asteroids that remained large (>10 km in diameter) during the late heavy bombardment.

Variability of sea salt and methanesulfonate in firn cores from northern Victoria Land, Antarctica: Their links to oceanic and atmospheric condition variability in the Ross Sea

Ro, Seokhyun., Hong, Sang-Bum., Kim, Joo-Hong., Han, Yeongcheol., Hur, Soon Do., Kang, Jung-Ho., Kim, Songyi., Lim, Changkyu., Chang, Chaewon., Moon, Jangil., Kim,

Seong-Joong. and Hong, Sungmin.

Frontiers in Earth Science. 2022. 10.

doi: 10.3389/feart.2022.896470

The potential ice core proxies of variability in oceanic and atmospheric conditions over the Ross Sea were evaluated. This study examined sea salt sodium ($ss-Na^+$) and biogenic sulfur (methanesulfonate, MS^-) records, covering 23 years between 1990 and 2012, from two firn cores drilled on the Styx Glacier plateau (SGP), northern Victoria Land, East Antarctica, to examine the potential links between those records and datasets for various climate variables. The comparison showed that the interannual variability of the $ss-Na^+$ record is closely related to Pacific–South American mode 2 (PSA2) in the Ross Sea sector, exhibiting an increased $ss-Na^+$ flux, owing most likely to more frequent penetration of maritime air masses from the western Ross Sea to the SGP when the winter/spring PSA2 mode becomes more pronounced. The observed MS^- record revealed statistically significant positive correlations with the changes in the summertime chlorophyll a concentration in the Ross Sea polynya (RSP) and wind speed in the southern Ross Sea region. This indicates the dominant role of a combination of changes in the summertime primary productivity and wind speed over the RSP in modulating the MS^- deposition flux at the SGP. These results highlight the suitability of the $ss-Na^+$ and MS^- records from the SGP as proxies for characterizing the dominant patterns of variability in oceanic and atmospheric conditions and their underlying mechanisms on interannual and longer timescales beyond the instrumental limits over the Ross Sea region.

keywords: Ross Sea; Styx firn cores; sea salt sodium; methanesulfonate; Pacific-South American mode; Ross Sea polynya

doi: 10.1016/j.palaeo.2022.110948

Magnetic susceptibility (MS) is routinely used as a proxy for terrigenous material input to Antarctic continental margin sediments. Variations in terrigenous input on glacial-interglacial timescales in this setting are related to a range of environmental changes; including to the cryosphere, atmosphere, and hydrosphere. However, the exact environmental factors and depositional processes that control MS values in sedimentary cores from the Antarctic continental margin remains unresolved. Here, we explore in detail sedimentary physical characteristics and MS values of core BS17-GC01 collected from Bellingshausen Sea continental rise, to understand how depositional process have varied during the late Quaternary. We found that input of terrigenous material increased markedly during Marine Isotope Stages (MIS) 2 and 4, compared to deposition during the adjacent interstadial and Holocene times. Variation in the bulk MS values were associated with changes in grain size. Size specific mass-normalized MS measurements show the fine fraction ($<16\ \mu m$) has the highest MS values, followed by the coarse silt fraction ($16-63\ \mu m$). However, because coarse silt is the predominant grain size, the increased bulk MS during MIS 2 and 4 are mainly driven by changes in this fraction. We propose that the coarse silt with high bulk MS values observed in glacial sediments were transported to the site as iceberg rafted debris, originating from the Bellingshausen Sea shelf region. In contrast, grains $>1\ mm$ – a commonly applied proxy for glacial transport in this setting – were observed during MIS 1 and 3 only. We conclude these contrasting signatures of iceberg rafted debris in this Bellingshausen Sea core arise from changes in the to the erosive dynamics of the adjacent ice shelf and continental shelf on glacial/interglacial timescales.

keywords: Magnetic susceptibility; Grain size; Ice-rafted debris; Coarse silt; Bellingshausen Sea

2-53 *Physical Geography; Geology; Paleontology*

Variation in magnetic susceptibility in the Bellingshausen Sea continental rise since the last glacial period and implications for terrigenous material input mechanisms

Kim, Sunghan., Lee, Min Kyung., Shin, Ji Young., **Yoo, Kyu-Cheul., Lee, Jae Il., Kang, Myung-Il., Moon, Heung Soo.** and Prebble, Joseph G.

Palaeogeography Palaeoclimatology Palaeoecology. 2022. 594.

3-1 Oceanography

Abundant microzooplankton possibly cause ultrahigh seawater dimethylsulfide during Southern Ocean algal blooms

Zhang, Miming., Booge, Dennis., Yan, Jinpei., Xu, Suqing., Liang, Chen., Wu, Yanfang., Yang, Bo., Wang, Jianjun., Zhao, Jun., Li, Dong., Pan, Jianming. and **Park, Keyhong.**

Progress in Oceanography. 2022. 202.

doi: 10.1016/j.pocean.2022.102744

Oceanic dimethylsulfide (DMS) is hypothesized to impact cloud formation and consequently the solar radiation budget of Earth's surface. Ultrahigh seawater DMS concentrations, up to hundreds of nM, have been observed in the Southern Ocean, attributing to concurrent high phytoplankton biomass. However, phytoplankton biomass cannot fully explain the mechanism leading to those extreme values. Herein, measurements, including seawater DMS concentrations and other biological and environmental parameters, were collected in the water column during the austral summer of 2015–2016 at the tip of the Antarctic Peninsula. Notably, large-scale ultrahigh seawater DMS concentrations (up to 85.2 nM and generally above 40 nM in the upper layer) was observed only in areas with co-existing phytoplankton blooms and abundant microzooplankton (indicated by ciliates, whose abundance and biomass were above 1000 ind L⁻¹ and 2 µg L⁻¹, respectively), implying that the grazing of abundant microzooplankton possibly causes the ultrahigh seawater DMS concentrations during the bloom seasons in the Southern Ocean.

keywords: Seawater dimethylsulfide; The Southern Ocean; Microzooplankton; Algal bloom; Ultrahigh values; Abundant

3-2 Environmental Sciences & Ecology; Meteorology & Atmospheric Sciences

Antarctic meltwater-induced dynamical changes in phytoplankton in the Southern Ocean

Oh, Ji-Hoon., Noh, Kyung Min., Lim, Hyung-Gyu., **Jin, Emilia Kyung., Jun, Sang-Yoon.** and Kug, Jong-Seong.

Environmental Research Letters. 2022. 17(2).

doi: 10.1088/1748-9326/ac444e

It has been suggested that the freshwater flux due to the recent melting of the Antarctic ice-sheet/shelf will suppress ventilation in the Southern Ocean (SO). In this study, we performed idealized earth-system simulations to examine the impacts of Antarctic meltwater on the biomass of surface phytoplankton in the Antarctic Ocean. The enhanced stratification due to the meltwater leads to a decrease in surface nitrate concentration, but an increase in the surface concentration of dissolved iron. These changes are associated with the reduced upwelling of nitrate-rich deep water and the trapped iron exported from terrestrial sediment. Because of the limited iron availability in the SO, the trapped iron in surface water enhances the chlorophyll concentration in the open ocean. However, in the marginal sea along the Antarctic coastline where the iron is relatively sufficient, a nitrate reduction induces a chlorophyll decrease, indicating a regime shift from iron-limited to nitrate-limited conditions.

keywords: Antarctic meltwater; Antarctic ice-sheet; shelf; Southern Ocean; chlorophyll; phytoplankton

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

Bacterial Metabolic Response to Change in Phytoplankton Communities and Resultant Effects on Carbon Cycles in the Amundsen Sea Polynya, Antarctica

Kim, Bomina., Kim, Sung-Han., Min, Jun-Oh., Lee, Youngju., Jung, Jinyoung., Kim, Tae-Wan., Lee, Jae Seong., **Yang, Eun Jin., Park, Jisoo., Lee, SangHoon.** and Hyun, Jung-Ho.

Frontiers in Marine Science. 2022. 9.

doi: 10.3389/fmars.2022.872052

We investigated changes in heterotrophic bacterial metabolic activities and associated carbon cycles in

response to a change in dominant phytoplankton communities during two contrasting environmental conditions in austral summer in the Amundsen Sea polynya (ASP), Antarctica: the closed polynya condition in 2014 (ANA04) and the open polynya condition in 2016 (ANA06). In ANA04, *Phaeocystis antarctica* predominated phytoplankton biomass, comprising 78% of total phytoplankton carbon biomass, whereas diatoms and *Dictyocha speculum* accounted for 45% and 48% of total phytoplankton carbon biomass, respectively, in ANA06. Bacterial production (BP) showed a significant positive correlation with only chlorophyll-a (Chl-a, $\rho = 0.66, p < 0.001$) in *P. antarctica*-dominated ANA04, whereas there were significant positive relationships of BP with various organic carbon pools, such as chromophoric dissolved organic matter (CDOM, $\rho = 0.84, p < 0.001$), Chl-a ($\rho = 0.59, p < 0.001$), and dissolved organic carbon (DOC, $\rho = 0.51, p = 0.001$), in ANA06 when diatoms and *D. speculum* co-dominated. These results indicate that BP depended more on DOC directly released from *P. antarctica* in ANA04, but was supported by DOC derived from various food web processes in the diatom-dominated system in ANA06. The BP to primary production (BP : PP) ratio was three-fold higher in *P. antarctica*-dominated ANA04 (BP : PP = 0.09), than in diatom- and *D. speculum*-co-dominated ANA06 (BP : PP = 0.03). These results suggested that the microbial loop is more significant in *Phaeocystis*-dominated conditions than in diatom-dominated conditions. In addition, the decreases in BP : PP ratio and bacterial respiration with increasing diatom proportion in the surface mixed layer indicated that the change from *P. antarctica* to diatom predominance enhanced biological carbon pump function by increasing particulate organic carbon export efficiency. Consequently, our results suggest that bacterial metabolic response to shifts in phytoplankton communities could ultimately affect larger-scale ecological and biogeochemical processes in the water column of the ASP.

keywords: bacterial production; bacterial respiration; phytoplankton community composition; microbial loop; biological pump; Amundsen Sea polynya; climate change

3-4 Oceanography

Behavioral responses of Adélie penguins confronting a giant ice floe

Park, Seongseop., Chung, Hosung. and Lee, Won Young.

Deep-Sea Research Part II-Topical Studies in Oceanography. 2022. 203.

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Recent rapid environmental changes in Antarctica have often produced a sudden barrier to the marine animals. Adélie penguins, one of the top predators in the Antarctic ecosystem, are reported to confront the changes near the habitats by the appearance of large icebergs or drift ice. We tracked the foraging trips of Adélie penguins with GPS and time-depth recorders during the chick-guarding period in December 2018, at Adélie Cove in the Ross Sea, Antarctica, when 240 km² of a giant ice floe was approaching near the foraging areas. Here, we aimed to investigate how Adélie penguins respond to these natural obstacles. Our results showed that, among the 18 penguins, 4 individuals moved to the south of the Silverfish Bay fast ice and 14 moved further east beyond the large ice floe to the sparse drift ice. The 14 birds on the sparse ice either crossed (through the ice floe surface, $n = 7$) or bypassed (to the northern ice boundary, $n = 2$; to the southern ice boundary, $n = 5$). Compared to a neighboring population on Inexpressible Island, Adélie Cove penguins had a longer foraging trip duration and movement distance. Our results suggest that the giant ice floe could alter the foraging paths and penguins bypassed or crossed the ice to reach their foraging areas by spending more energy and time. For better understanding, further studies are required to estimate if penguins suffer from these changes.

keywords: Ice floe; Ross sea; Antarctica; GPS; Time -depth recorders

3-5 Microbiology

Biogeography of Southern Ocean Active Prokaryotic Communities Over a Large Spatial Scale

Maturana-Martinez., Claudia, Iriarte., Jose Luis., Ha, Sun-Yong., Lee, Boyeon., Ahn, In-Young. and 5 others.

Frontiers in Microbiology. 2022. 13.

doi: 10.3389/fmicb.2022.862812

The activity of marine microorganisms depends on community composition, yet, in some oceans, less is known about the environmental and ecological processes that structure their distribution. The objective of this study was to test the effect of geographical distance and environmental parameters on prokaryotic community structure in the Southern Ocean (SO). We described the total (16S rRNA gene) and the active fraction (16S rRNA-based) of surface microbial communities over a ~6,500 km longitudinal transect in the SO. We found that the community composition of the total fraction was different from the active fraction across the zones investigated. In addition, higher α -diversity and stronger species turnover were displayed in the active community compared to the total community. *Oceanospirillales*, *Alteromonadales*, *Rhodobacterales*, and *Flavobacteriales* dominated the composition of the bacterioplankton communities; however, there were marked differences at the order level. Temperature, salinity, silicic acid, particulate organic nitrogen, and particulate organic carbon correlated with the composition of bacterioplankton communities. A strong distance-decay pattern between closer and distant communities was observed. We hypothesize that it was related to the different oceanic fronts present in the Antarctic Circumpolar Current. Our findings contribute to a better understanding of the complex arrangement that shapes the structure of bacterioplankton communities in the SO.

keywords: DNA; RNA; Southern Ocean; fjord; biogeography

in the surface waters (up to 500 W m^{-2}) favour chlorophyll (sensitizer) photobleaching at the expense of Type II photosensitized oxidation of unsaturated lipid components of phyto- and zooplankton (photodynamic effect). The weak photoreactivity of wax esters of herbivorous zooplankton in these SPM samples contrasts with previous observations of strong photooxidation of these compounds in sinking particles, which suggests that the photodynamic effect should be favoured in large faecal pellets of herbivorous copepods sinking quickly in weakly irradiated zones. Autoxidation (free radical induced oxidation) processes operating in all oxic environments appeared to be particularly efficient in faecal pellets of omnivorous and carnivorous zooplankton and limited in those of herbivorous origin. These differences were attributed to the consumption of algal antioxidants (such as mycosporine-like amino acids and carotenoids) during the diet of omnivorous and carnivorous copepods, favouring the involvement of free radical oxidation processes.

keywords: Chukchi Sea; SPM; Lipids; Biotic and abiotic oxidation

3-6 Chemistry; Oceanography

Biotic and abiotic degradation of suspended particulate lipids along a transect in the Chukchi Sea

Rontani, Jean-Francois., Smik, Lukas., **Ha, Sun-Yong, Min, Jun-oh.** and Belt, Simon T.

Marine Chemistry. 2022. 241.

doi: 10.1016/j.marchem.2022.104109

Lipids and their degradation products were investigated in samples of suspended particulate matter (SPM) collected in summer 2015 from surface waters of a South-North transect (ca. 65–81°N) of the Chukchi Sea. This material appeared to be composed mainly of diatoms (dominated by *Thalassiosirales*) and copepod faecal pellet debris. The high solar irradiances measured

3-7 Oceanography

Changes in Arctic Halocline Waters Along the East Siberian Slope and in the Makarov Basin From 2007 to 2020

Bertosio, Cecilia., Provost, Christine., Athanase, Marylou., Sennechael, Nathalie., Garric, Gilles., Lellouche, Jean-Michel., **Kim, Joo-Hong, Cho, Kyoung-Ho.** and **Park, Taewook**

Journal of Geophysical Research-Oceans. 2022. 127(9).

doi: 10.1029/2021jc018082

The evolution of halocline waters in the Makarov Basin and along the East Siberian continental slope is examined by combining drifting platform observations, shipborne hydrographic data, and simulations from a global operational physical model from 2007 to 2020. From 2012 onwards, relatively shallow and cold Atlantic-derived lower halocline waters, previously restricted to the Lomonosov Ridge area, progressed eastward along the East Siberian continental slope. Their eastward extent abruptly shifted from 155°E to 170°E in early 2012, stabilized at 170°E until the end of 2015, then gradually advanced to reach the western Chukchi Sea in 2017. Such eastward progression led to

a strengthening of the associated boundary current and to the shedding of mesoscale eddies of cold Atlantic-derived waters into the lower halocline of the Makarov Basin in September 2015 and near the East Siberian continental slope in November 2017. Additionally, active mixing between upwelled Atlantic Water and shelf water formed dense warm water supplying the Makarov Basin lower halocline. The increasing contribution from Atlantic-derived waters into the lower halocline along the East Siberian continental slope and in the Makarov Basin led to a weakening of the halocline, which is characteristic of a new Arctic Ocean regime that started in the early 2000s in the Eurasian Basin. Our results suggest that this new Arctic regime may now extend toward the Amerasian Basin.

keywords: Arctic Ocean; halocline; Makarov Basin; model

3-8 *Environmental Sciences & Ecology; Marine & Freshwater Biology; Microbiology*

Changes in Fecal Pellet Microbiome of the Cold-Adapted Antarctic Copepod *Tigriopus kingsejongensis* at Different Temperatures and Developmental Stages

Oh, Han Na., **Myeong, Nu Ri.**, Kim, Taeyune., Min, Gi-Sik., **Kim, Sanghee.** and Sul, Woo Jun.

Microbial Ecology. 2022. 84(4): 1029-1041.

doi: 10.1007/s00248-021-01928-z

Tigriopus kingsejongensis, a copepod species reported from the King Sejong Station, Antarctica, serves as a valuable food resource in ecosystems. We cultured *T. kingsejongensis* at three different temperatures (2 °C, 8 °C, and 15 °C) in a laboratory to observe the changes in its fecal pellet microbiome depending on the cultivation temperatures and developmental stages. We observed that the fecal pellet microbiome of the copepod changed with temperature: a lower microbial diversity, higher abundance of the aquatic bacterium *Vibrio*, and lower abundance of the psychrophilic bacterium *Colwellia* were noted at higher temperatures. In addition, the fecal pellet microbiome of the copepod changed according to the developmental stage: a lower microbial diversity was noted in egg-attached copepods than in nauplii at 8 °C. We further analyzed three shotgun metagenomes from the fecal pellet samples of *T. kingsejongensis* at different temperatures and obtained 44 metagenome-assembled genomes (MAGs).

We noted that MAGs of *V. splendidus* D contained glycosyl hydrolases (GHs) encoding chitinases and virulence factors at a higher relative abundance at 15 °C than at lower temperatures. These results indicate that increasing temperature affects the fecal pellet microbiome and the development of copepods. The findings are helpful to understand the changes in cold-adapted copepods and the effect of temperature on their growth.

keywords: Antarctica; Copepods; Fecal pellet microbiome; Temperature; Virulence factors; Chitinase

3-9 *Oceanography*

Changes in Freshwater Distribution and Pathways in the Arctic Ocean Since 2007 in the Mercator Ocean Global Operational System

Bertosio, Cecilia., Provost, Christine., Athanase, Marylou., Sennechael, Nathalie., Garric, Gilles., Lellouche, Jean-Michel., Bricaud, Clement., **Kim, Joo-Hong., Cho, Kyoung-Ho.** and **Park, Taewook.**

Journal of Geophysical Research-Oceans. 2022. 127(6).

doi: 10.1029/2021jc017701

Low-salinity waters in the upper Arctic Ocean, referred to as “freshwaters”, are cold and play a major role in isolating the sea ice cover from the heat stored in the salty Atlantic Waters (AW) underneath. We examined changes in Arctic freshwater distribution and circulation since 2007 using the 1/12° global Mercator Ocean operational model. We first evaluated model simulations over the upper water column in the Arctic Ocean, using nearly 20,000 independent in situ temperature-salinity profiles over the 2007–2020 period. Simulated hydrographic properties and water mass distributions were in good agreement with observations. Comparison with long-term mooring data in the Bering Strait and Beaufort Gyre highlighted the model's capabilities for reproducing the interannual evolution of Pacific Water properties. Taking advantage of the good performance of the model, we examined the interannual evolution of the freshwater distribution and circulation over 2007–2020. The Beaufort Gyre is the major freshwater reservoir across the full Arctic Ocean. After 2012 the gyre extended northward and increased the freshwater content in the Makarov Basin, near the North Pole. Coincidentally, the freshwater content decreased along the East Siberian slope, along

with the AW shoaling, and the Transpolar Drift moved from the Lomonosov Ridge to align with the Mendeleev Ridge. We found that these changes in freshwater distribution were followed in 2015 by a marked change in the export of freshwater from the Arctic Ocean with a reduction in Fram Strait (−30%) and an increase in the western Canadian Archipelago (+16%).

keywords: Arctic Ocean; freshwater; Mercator Ocean global system; Beaufort Gyre

3-10 *Marine & Freshwater Biology; Oceanography*

Changes in the burial efficiency and composition of terrestrial organic carbon along the Mackenzie Trough in the Beaufort Sea

Kim, Dahae., Kim, Jung-Hyun., Tesi, Tommaso., Kang, Sujin., Nogarotto, Alessio., **Park, Kwangkyu.,** Lee, Dong-Hun., **Jin, Young Keun.,** Shin, Kyung-Hoon. and **Nam, Seung-Il.**

Estuarine Coastal and Shelf Science. 2022. 275.

doi: 10.1016/j.ecss.2022.107997

In this study, we investigated surface sediments collected along a Mackenzie Trough transect during the R/V Araon expeditions (ARA04C, ARA05C, and ARA08C) in the Beaufort Sea in 2013, 2014, and 2017. We applied various inorganic and organic geochemical tools (major elements, carbon and nitrogen contents, stable carbon and radiocarbon isotope compositions, and molecular biomarkers) in combination with sedimentological measurements (mineral surface area (SA) and grain size) to assess the source and burial characteristics of organic carbon (OC). In general, the sediment mean grain size decreased with water depth whereas the SA increased, resulting in a decrease in the OC loading and the burial efficiency of terrestrial OC. The sedimentary OC was further influenced by the loss of terrestrial OC and replacement with marine OC with increasing water depth. Accordingly, our results suggest that hydrodynamic sorting and degradation of terrestrial OC co-occurred together with the enrichment of marine OC with distance offshore. Such processes controlled the burial and reactivity of terrestrial OC along the Mackenzie Trough transect.

keywords: Beaufort sea; Mackenzie trough; Terrestrial organic carbon; $\delta^{13}\text{C}$; $\Delta^{14}\text{C}$; *n*-alkanes; Lignin phenols

3-11

Classification of bearded seals signal based on convolutional neural network

Kim, Ji Seop., Yoon, Young Geul., **Han, Dong-Gyun., La, Hyoung Sul.** and Choi, Jee Woong.

The Journal of the Acoustical Society of Korea. 2022. 41(2): 235-241.

doi: 10.7776/ASK.2022.41.2.235

Several studies using Convolutional Neural Network (CNN) have been conducted to detect and classify the sounds of marine mammals in underwater acoustic data collected through passive acoustic monitoring. In this study, the possibility of automatic classification of bearded seal sounds was confirmed using a CNN model based on the underwater acoustic spectrogram images collected from August 2017 to August 2018 in East Siberian Sea. When only the clear seal sound was used as training dataset, overfitting due to memorization was occurred. By evaluating the entire training data by replacing some training data with data containing noise, it was confirmed that overfitting was prevented as the model was generalized more than before with accuracy (0.9743), precision (0.9783), recall (0.9520). As a result, the performance of the classification model for bearded seals signal has improved when the noise was included in the training data.

keywords: Passive acoustic monitoring; Bearded seal; Deep learning; Convolution neural network; Classification

3-12 *Environmental Sciences & Ecology; Marine & Freshwater Biology*

Climate warming-driven changes in the flux of dissolved organic matter and its effects on bacterial communities in the Arctic Ocean: A review

Nguyen, Hien Thi., **Lee, Yung Mi., Hong, Jong Kuk.** and 3 others.

Frontiers in Marine Science. 2022. 9.

doi: 10.3389/fmars.2022.968583

The warming of the Arctic Ocean impacts the dissolved organic matter (DOM) imports into the Arctic region, which affects the local bacterial communities. This review addressed the current status of DOM inputs and their potential influences on bacteria data (e.g., population, production, and metabolic activity of

bacteria), as well as the projected changes of DOM inputs and bacterial communities as a result of climate warming. Microbial communities are likely affected by the warming climate and the transport of DOM to the Arctic Ocean. Imported DOM can alter Arctic bacterial abundance, cell size, metabolism, and composition. DOM fluxes from Arctic River runoff and adjacent oceans have been enhanced, with warming increasing the contribution of many emerging DOM sources, such as phytoplankton production, melted sea ice, thawed permafrost soil, thawed subsea permafrost, melted glaciers/ice sheets, atmospheric deposition, groundwater discharge, and sediment efflux. Imported DOM contains both allochthonous and autochthonous components; a large quantity of labile DOM comes from emerging sources. As a result, the Arctic sea water DOM composition is transformed to include a wider range of various organic constituents such as carbohydrates (i.e., glucose), proteinaceous compounds (i.e., amino acid and protein-like components) and those with terrigenous origins (i.e., humic-like components). Changes to DOM imports can alter Arctic bacterial abundance, cell size, metabolism, and composition. Under current global warming projections, increased inflow of DOM and more diverse DOM composition would eventually lead to enhanced CO₂ emissions and frequent emergence of replacement bacterial communities in the Arctic Ocean. Understanding the changes in DOM fluxes and responses of bacteria in the Arctic broadens our current knowledge of the Arctic Ocean's responses to global warming.

keywords: Arctic Ocean; bacterial communities; climate warming; dissolved organic matter; sea water

in melting sea ice and the loss of glaciers, which have consequently caused substantial changes in biodiversity. Samples of pelagic ciliates from 13 sites were collected as bioindicators to demonstrate the relationship between spatial distribution patterns and environmental heterogeneity affected by sea ice melting and to reveal the community assembly mechanisms in the Ross Sea. Univariate analyses and multivariate analyses were effective tools demonstrating clear spatial patterns and providing a sufficient explanation to interpret strong correlations between pelagic ciliate communities and environmental variations, especially the distribution pattern of nutrients and Chl *a*. Moreover, environmental heterogeneity might affect the co-occurrence network complexity of ciliate communities. Furthermore, our results also indicated that stochastic processes play a significant role in the community assembly of pelagic ciliates. This study examined the controlling mechanisms of environmental heterogeneity affected by sea ice melting on pelagic ciliate communities and provided explanations for the community assembly of pelagic ciliates in polar marine ecosystems.

keywords: Spatial pattern; Co-occurrence network; Ciliated protozoa; Community assembly; Southern Ocean

3-13 *Environmental Sciences & Ecology*

Community assembly and co-occurrence network complexity of pelagic ciliates in response to environmental heterogeneity affected by sea ice melting in the Ross Sea, Antarctica

Yu, Xiaowen., Li, Xianrong., Liu, Qian., Yang, Mengyao., Wang, Xiaoxiao., Guan, Zhenyu., Yang, Jinpeng., Liu, Mingjian., **Yang, Eun Jin.** and Jiang, Yong.

Science of the Total Environment. 2022. 836.

doi: 10.1016/j.scitotenv.2022.155695

In the Southern Ocean, the living environment of organisms has changed due to the dramatic increase

3-14 *Marine & Freshwater Biology; Oceanography*

The composition and abundance of phytoplankton after spring bloom in the Arctic Svalbard fjords

Bae, Seongjun., Kim, Haryun., **Nam, Seung-II.** and 10 others.
Estuarine Coastal and Shelf Science. 2022. 275.

doi: 10.1016/j.ecss.2022.107970

Glacial melting and massive spring blooms caused by global warming have significantly altered the environmental conditions in the Svalbard fjords of the European Arctic. These changes included reduced salinity (the gradient of salinity from inner to outer fjords, ranging from 23 to 34 PSU), stratification of the water column, increased turbidity (>135 FTU), low nutrient conditions (0.06–1.13 μM PO₄³⁻, 1.19–3.54 μM NO₃⁻, 1.19–3.54 μM NH₄⁺, and –2.1 to 0.9 N*), reduced light penetration, and release of organic matter, resulting in changes in the structure and composition of the phytoplankton. Our study, conducted in Isfjorden, van Mijenfjorden/Bellsund, and Hornsund of Svalbard in early August 2019, observed the dominance of

cryptophytes in the phytoplankton composition after the spring bloom. Our results show a different phenomenon from the previous diatom/dinoflagellate dominance in the late 1970s and the early 2020s. Changes in phytoplankton composition can be explained as follows. (1) The excessive consumption of nutrients during spring bloom and the reduction of nutrient mixing in the water column stratification due to glacier melting has formed nutrient-depleted conditions, providing favorable conditions for the small-sized phytoplankton that easily find nutrients. (2) A wide range of salinities has created beneficial conditions for cryptophytes, capable of controlling osmotic stress against various salinities, of surviving compared to diatoms and dinoflagellates. (3) Finally, the influx of organic matter into fjords due to glacier melting can increase turbidity and decrease light availability; therefore, cryptophytes with mixotrophic metabolisms could be more viable than diatoms with only autotrophic metabolisms. In summary, the dynamic environmental conditions after enhanced spring bloom and glacier melting will further alter phytoplankton compositions and, in turn, influence food webs at higher trophic levels in European Arctic fjord ecosystems.

keywords: Cryptophyceae; Diatom; Dinophyceae; Glacier melting; Phytoplankton; Svalbard fjords

2016 (ARA07B) and 2017 (OS040). Diatoms and phaeocystis were dominant phytoplankton communities in 2016 whereas diatoms and Prasinophytes (Type 2) were dominant in 2017 and diatoms were found as major contributors for the small phytoplankton groups. For size-specific primary production, small phytoplankton contributed 38.0% (SD = $\pm 19.9\%$) in 2016 whereas 25.0% (SD = $\pm 12.8\%$) in 2017 to the total primary productivity. The small phytoplankton contribution observed in 2016 is comparable to those reported previously in the Chukchi Sea whereas the contribution in 2017 mainly in the northern Bering Sea is considerably lower than those in other arctic regions. Different biochemical compositions were distinct between small and large phytoplankton in this study, which is consistent with previous results. Significantly higher carbon (C) and nitrogen (N) contents per unit of chlorophyll-a, whereas lower C:N ratios were characteristics in small phytoplankton in comparison to large phytoplankton. Given these results, we could conclude that small phytoplankton synthesize nitrogen-rich particulate organic carbon which could be easily regenerated.

keywords: Bering Sea; Chukchi Sea; HPLC; small phytoplankton; primary productivity

3-15 *Environmental Sciences & Ecology; Water Resources*

Contribution of Small Phytoplankton to Primary Production in the Northern Bering and Chukchi Seas

Park, Jung-Woo., Kim, Yejin., Kim, Kwan-Woo., Fujiwara, Amane., Waga, Hisatomo., Kang, Jae Joong., Lee, Sang-Heon., **Yang, Eun-Jin.** and Hirawake, Toru.

Water. 2022. 14(2).

doi: 10.3390/w14020235

The northern Bering and Chukchi seas are biologically productive regions but, recently, unprecedented environmental changes have been reported. For investigating the dominant phytoplankton communities and relative contribution of small phytoplankton (<2 μm) to the total primary production in the regions, field measurements mainly for high-performance liquid chromatography (HPLC) and size-specific primary productivity were conducted in the northern Bering and Chukchi seas during summer

3-16 *Environmental Sciences & Ecology*

Detection method for diel vertical migration pattern using 2D cross-correlation with ADCP backscatter time-series data

Chun, Sehwa., La, Hyoung Sul., Son, Wuju., Kim, Young Cheol., Cho, Kyoung-Ho. and Yang, Eun Jin.

Methods in Ecology and Evolution. 2022. 13(7): 1475-1487.

doi: 10.1111/2041-210x.13871

1. Diel vertical migration (DVM), which refers to the global daily migration of zooplankton and micronekton (hereafter 'zooplankton'), serves an important function in oceanic ecosystems. DVM can be recognized as a variation in the sound scattering layer (SSL), but no standard exists for identifying SSLs, and no definition has been proposed to describe the basic features of DVM. Hence, a standardized DVM detection method is needed to report consistent results and efficiently compare the parameters over broad ocean areas and long time-scales.
2. We developed an automated, quantitative method

for detecting DVM and identifying the characteristic parameters using 2D cross-correlation. We established the DVM trajectory model with linear and sinusoidal parts featuring a specific height and width. The 2D cross-correlation method was applied to acoustic echogram images of the volume backscattering strength (Sv, dB re 1 m⁻¹) with a synthetic image made from the DVM trajectory model. From the cross-correlation coefficients, we found the candidate lines exhibiting the strongest possibility of being DVM trajectories.

3. We tested the DVM detection method on the acoustic echograms for 273 days, of which Sv was gathered by a bottom-moored, upward-looking acoustic Doppler current profiler (ADCP). For each identified DVM trajectory, four quantitative parameters describing their spatial and temporal structures (the maximum and minimum depths and ascent and descent times) were determined, and the existence of multi-layer was recognized. We confirmed that this method showed better performance than the prior method based on the weighted mean depth (WMD), and as a result of visual scrutiny inspection, our method showed 88% DVM detection performance.
4. Our goal was to suggest a robust, quantitative, automated DVM detection method using 2D cross-correlation. The method was successfully applied to detect DVM trajectories and define the characteristic parameters regardless of fluctuation or the multi-layer structure due to its robustness and simple model. Analysing DVM behaviours across environments with this method could help reveal the significance of these behaviours in ocean environments.

keywords: ADCP; Acoustic backscatter; Cross-correlation; Diel Vertical Migration; Sound scattering layers; Zooplankton

3-17 *Oceanography*

Development of a Noble Gas Isotope Dilution Mass Spectrometric System Combined with a Cryogenic Cold Trap

Hong, bongjae., Shin, DongYoub., **Park, Keyhong.** and Hahm, Doshik.

Journal of the Korean Society of Oceanography. 2022. 27(3): 144-157.

doi: 10.7850/jkso.2022.27.3.144

Noble gases, which are chemically inert and behave conservatively in marine environments, have been used as tracers of physical processes such as air-sea gas exchange, mixing of water masses, and distribution of glacial meltwater in the ocean. For precise measurements of Ne, Ar, and Kr, we developed a mass spectrometric system consisting of a quadrupole mass spectrometer (QMS), a high vacuum preparation line, an activated charcoal cryogenic trap (ACC), and a set of isotope standard gases. The high vacuum line consists of three sections: (1) a sample extraction section that extracts the dissolved gases in the sample and mixes them with the standard gases, (2) a gas preparation section that removes reactive gases using getters and separates the noble gases according to their evaporation points with the ACC, and (3) a gas analysis section that measures concentrations of each noble gas. The ACC attached to the gas preparation section markedly lowered the partial pressures of Ar and CO₂ in the QMS, which resulted in a reduced uncertainty of Ne isotope analysis. The isotope standard gases were prepared by mixing ²²Ne, ³⁶Ar, and ⁸⁶Kr. The amounts of each element in the mixed standard gases were determined by the reverse isotope dilution method with repeated measurements of the atmosphere. The analytical system achieved precisions for Ne, Ar, and Kr concentrations of 0.7%, 0.7%, and 0.4%, respectively. The accuracies confirmed by the analyses of air-equilibrated water were 0.5%, 1.0%, and 1.7% for Ne, Ar, and Kr, respectively.

keywords: Noble gases; Isotope dilution mass spectrometry; Cryogenic cold trap; Neon; Argon; Krypton;

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

Distribution and Production of N₂O in the Subtropical Western North Pacific Ocean During the Spring of 2020

Heo, Jang-Mu., Kim, Hyo-Ryeon., Eom, Sang-Min., Yoon, Joo-Eun., Shim, JeongHee., Lim, Jae-Hyun., Kim, Ju-Hyoung., Thangaraj, Satheeswaran., **Park, Ki-Tae.** and 2 others.

Frontiers in Marine Science. 2022. 9.

doi: 10.3389/fmars.2022.854651

Nitrous oxide (N₂O) is an important greenhouse gas emitted in significant volumes by the Pacific Ocean. However, the relationship between N₂O dynamics and

environmental drivers in the subtropical western North Pacific Ocean (STWNPO) remains poorly understood. We investigated the distribution of N_2O and its production as well as the related mechanisms at the surface (0–200 m), intermediate (200–1500 m), and deep (1500–5774 m) layers of the STWNPO, which were divided according to the distribution of water masses. We applied the transit time distribution (TTD) method to determine the ventilation times, and to estimate the N_2O equilibrium concentration of water parcels last in contact with the atmosphere prior to being ventilated. In the surface layer, biologically derived N_2O ($\Delta\text{N}_2\text{O}$) was positively correlated with the apparent oxygen utilization (AOU) ($R^2 = 0.48$), suggesting that surface N_2O may be produced by nitrification. In the intermediate layer, $\Delta\text{N}_2\text{O}$ was positively correlated with AOU and NO_3^- ($R^2 = 0.92$ and $R^2 = 0.91$, respectively) and negatively correlated with nitrogen sinks (N^*) ($R^2 = 0.60$). Hence, the highest $\Delta\text{N}_2\text{O}$ value in the oxygen minimum layer suggested N_2O production through nitrification and potential denitrification (up to 51% and 25% of measured N_2O , respectively). In contrast, the deep layer exhibited a positive correlation between $\Delta\text{N}_2\text{O}$ and AOU ($R^2 = 0.92$), suggesting that the N_2O accumulation in this layer may be caused by nitrification. Our results demonstrate that the STWNPO serves as an apparent source of atmospheric N_2O (mean air–sea flux $2.0 \pm 0.3 \mu\text{mol m}^{-2} \text{d}^{-1}$), and that nitrification and potential denitrification may be the primary mechanisms of N_2O production in the STWNPO. We predict that ongoing ocean warming, deoxygenation, acidification, and anthropogenic nitrogen deposition in the STWNPO may elevate N_2O emissions in the future. Therefore, the results obtained here are important for elucidating the relationships between N_2O dynamics and environmental changes in the STWNPO and the global ocean.

keywords: nitrous oxide; greenhouse gas; North Pacific Ocean; oxygen minimum layer; air–sea gas exchange; climate change

Frontiers in Marine Science. 2022. 9.

doi: 10.3389/fmars.2022.1022957

Interactions between phytoplankton and ultraviolet radiation (UVR: 280 – 400 nm) are undergoing changes dictated by variability in ocean temperature, the depth of mixed layers, nutrient availability, and the thickness of the ozone layer. There are a variety of mechanisms for phytoplankton to cope with UVR stress, one of the most prevalent being the presence of mycosporine-like amino acids (MAAs). Despite the importance of these molecules to phytoplankton fitness under UVR stress, knowledge of the diversity and distribution of these molecules in the world's oceans is relatively limited. Here, the composition and distribution of MAAs in phytoplankton were examined in a transect across the Southern Ocean, crossing multiple fronts, from eastern New Zealand to the West Antarctic Peninsula in March and April of 2018. The highest concentration of MAAs ($> 0.2 \mu\text{g/L}$) was found between 50 and 60°S, as well as along a longitudinal gradient between 137.47 and 144.78°W. A strong correlation was found between a model of the preceding month's UVR dosage experienced in the mixed layer and the ratio of MAAs to chlorophyll-a across the transect, indicating a relationship between the integrated history of light exposure and phytoplankton physiology. Haptophytes accounted for the majority of biomass north of the polar front (PF) and were strongly correlated with a diversity of MAAs. South of the PF a transition to a community dominated by diatoms was observed, with community composition changes strongly correlated to porphyra-334 concentrations. The data presented here provide a baseline for MAA abundance and association with specific phytoplankton taxa across the Southern Ocean amid a changing climate.

keywords: MAAs; Southern Ocean; UV-absorbing compounds; diatoms; mycosporine-like amino acids; phytoplankton; sunscreens; ultraviolet radiation

3-19 *Environmental Sciences & Ecology; Marine & Freshwater Biology*

The distribution of mycosporine-like amino acids in phytoplankton across a Southern Ocean transect

Weiss, Elliot L. L., Cape, Mattias Rolf., Pan, B. Jack., Vernet, Maria., James, Chase C. C., Smyth, Tim J. J., **Ha, Sun-Yong.** and 2 others.

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

Distribution of the Mesozooplankton Community in the Western Ross Sea Region Marine Protected Area During Late Summer Bloom

Kim, Sung Hoon., Kim, Bo Kyung., Lee, Boyeon., Son, Wuju., Jo, Naeun., Lee, Junbeom., Lee, Sang Heon., Ha,

Sun-Yong, Kim, Jeong-Hoon. and La, Hyoung Sul.

Frontiers in Marine Science. 2022. 9.

doi: 10.3389/fmars.2022.860025

The spatio-temporal distributions of the epipelagic mesozooplankton community in the western Ross Sea region marine protected area (RSR MPA) were investigated. Mesozooplankton surveys were conducted in February 2018, January 2019, and March 2020 from an approximate depth of 200 m to address the essential environmental factors influencing the mesozooplankton community structure. Our results showed that the mesozooplankton community of the western RSR MPA could be affected by the various ecological factors, depending on their temporal and spatial variations. The community structure in 2018 was distinguished by its chlorophyll-*a* (Chl-*a*) concentration during the summer bloom phase in the late summer. Taxa observed in 2019 were divided into four significantly different groups according to the body size of the community composition. This differentiation could be derived from predation pressure, inducing a trophic cascade. Taxa in the 2020 samples were separated into five different groups based on temperature; during the 2020 survey, the water temperature was low and sea ice covered the whole continental shelf in the Ross Sea. Additionally, comparing the results from the three interannual surveys, although the communities clustered according to the survey period, the continental shelf groups were quite dissimilar despite overlapping geographically. Taken all together, the mesozooplankton community of the western RSR MPA changed according to changes in several ecological factors, such as temperature, Chl-*a* concentration, and predation pressure. The occurrence of summer blooms and the decline in water temperature mainly regulated the mesozooplankton community structure in the late summer.

keywords: mesozooplankton; community structure; Ross Sea region marine protected area (MPA); late summer bloom; epipelagic

Youngju. and 2 others.

Microorganisms. 2022. 10(10).

doi: 10.3390/microorganisms10101967

Whether phytoplankton mortality is caused by grazing or viral lysis has important implications for phytoplankton dynamics and biogeochemical cycling. The ecological relevance of viral lysis for Antarctic phytoplankton is still under-studied. The Amundsen Sea is highly productive in spring and summer, especially in the Amundsen Sea Polynya (ASP), and very sensitive to global warming-induced ice-melt. This study reports on the importance of the viral lysis, compared to grazing, of pico- and nanophytoplankton, using the modified dilution method (based on apparent growth rates) in combination with flow cytometry and size fractionation. Considerable viral lysis was shown for all phytoplankton populations, independent of sampling location and cell size. In contrast, the average grazing rate was 116% higher for the larger nanophytoplankton, and grazing was also higher in the ASP (0.45 d^{-1} vs. 0.30 d^{-1} outside). Despite average specific viral lysis rates being lower than grazing rates (0.17 d^{-1} vs. 0.29 d^{-1}), the average amount of phytoplankton carbon lost was similar ($0.6 \mu\text{g C L}^{-1} \text{ d}^{-1}$ each). The viral lysis of the larger-sized phytoplankton populations (including diatoms) and the high lysis rates of the abundant *P. antarctica* contributed substantially to the carbon lost. Our results demonstrate that viral lysis is a principal loss factor to consider for Southern Ocean phytoplankton communities and ecosystem production.

keywords: Antarctic phytoplankton; Amundsen Sea Polynya; carbon flux; viral lysis; microzooplankton grazing; Southern Ocean

3-21 Microbiology

Ecological Importance of Viral Lysis as a Loss Factor of Phytoplankton in the Amundsen Sea

Eich, Charlotte., Biggs, Tristan E. G., van de Poll, Willem H., van Manen, Mathijs., Tian, Hung-An, **Jung, Jinyoung., Lee,**

3-22 Environmental Sciences & Ecology; Marine & Freshwater Biology

Ecological Responses of Core Phytoplankton by Latitudinal Differences in the Arctic Ocean in Late Summer Revealed by 18S rDNA Metabarcoding

Joo, Hyoung Min., Kim, Kang Eun., Park, Joon Sang., Kim, Hyun-Jung., **Yang, Eun Jin.,** Lee, Taek-Kyun., **Cho, Kyoung-Ho., Jung, Jinyoung., Lee, Youngju., Kang, Sung-Ho. and Jung, Seung Won.**

Frontiers in Marine Science. 2022. 9.

doi: 10.3389/fmars.2022.879911

Limited information is available regarding the phytoplankton communities in the Arctic Ocean, especially in the Chukchi Sea. We conducted research cruises in the Arctic Ocean in the late summers of 2015, 2016, 2018, and 2019, and used 18S ribosomal DNA metabarcoding to examine the dynamic changes in core phytoplankton. Environmental factors were divided into three Groups: “surface layers in low latitude”, “subsurface chlorophyll maximum layers in low latitude”, and “high latitude.” The phytoplankton community was divided into two Groups. One Group, “the phytoplankton community in lower latitudes affected by the Pacific Influx”, comprised Dinophyta (56.33%), Bacillariophyta (22.28%), and Chlorophyta (20.77%), while the other Group, “the phytoplankton community in higher latitudes affected by the Arctic Sea”, comprised Dinophyta (57.51%), Bacillariophyta (10.71%), and Chlorophyta (27.57%). The common phytoplankton taxa in Group of lower latitudes included 33 operational taxonomic units (OTUs) (99.04%), while the other Group included nine OTUs (98.80%). In these groups, OTUs #005 (*Heterocapsa rotundata*), #001 (*Micromonas pusilla*), and #003 (*Chaetoceros gelidus*) were core OTUs (>5%). These core OTUs were significantly different between the two Groups; OTU #001 and #003 were distributed at high relative abundance and rapidly increased at higher latitudes. OTU #005 showed a relatively high abundance at lower latitudes. Analysis of the indicator species revealed that 34 OTUs in lower latitudes and only one OTU (#003) in higher latitudes were observed to have a strong value of >0.8. Our results indicate that core phytoplankton taxa and community structures by latitudinal differences are highly dependent on different water masses and show their dynamic ecological responses to extreme environmental conditions.

keywords: Arctic Ocean; core phytoplankton; latitudinal differences; 18S metabarcoding; nano- and pico-phytoplankton

Fishery demand for Antarctic krill is increasing, and projected to continue increasing into the future. Krill has the potential to contribute approximately 10% to all future marine landings, adding significantly to global food security. However, the fishery is effectively data-limited so is currently managed using precautionary assessments that relate to large spatial and temporal scales that preclude the need for fine-scale ecological data. To respond to recent changes in fishery operation and to mitigate possible ecological impacts, the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) plans to revise its management strategy so that it takes into account ecosystem operation at smaller spatial and temporal scales, such as those relevant to krill-dependent predators. Here, we consider how catches in coastal areas potentially present challenges for these predators, where cumulative catches over the fishing season can sometimes be greater than local consumption by predators, and sometimes greater than the standing stock of krill within an area because of krill transport and replenishment by ocean currents. Protecting feeding areas used by land-based predators such as penguins and seals, whilst also offering a high level of protection for pelagic predators such as some species of fish and recovering populations of cetaceans, will require innovative solutions. We highlight critical ecological research needed to reduce management uncertainty. This is important as we demonstrate that krill consumption by predators in near-shore coastal habitats relies absolutely upon krill movement and oceanographic transport. We also highlight the need to improve understanding about krill behaviour, especially in relation to observed seasonal changes in krill biomass. Finally, we highlight that without up-to-date data about changes in krill, krill-dependent predator populations and their oceanographic environment, management will remain challenging in the context of increasing fishing pressure, recovering populations of marine mammals and a changing climate.

keywords: Antarctic krill; Krill-dependent predators; Predator krill consumption; Oceanography; Krill flux; Ecosystem approach to fishery management

3-23 *Geology; Marine & Freshwater Biology; Oceanography*

The ecosystem approach to management of the Antarctic krill fishery-the 'devils are in the detail' at small spatial and temporal scales

Trathan, P. N., Warwick-Evans, V., Young, E. F., Friedlaender, A., Kim, Jeong-Hoon. and Kokubun, N.

Journal of Marine Systems. 2022. 225.

doi: 10.1016/j.jmarsys.2021.103598

3-24 *Environmental Sciences & Ecology; Water Resources*

Energy Optimization Techniques in Underwater Internet of Things: Issues, State-of-the-Art, and Future Directions

Mary, Delphin Raj Kesari., Ko, Eunbi., **Yoon, Dong Jin.** and 2 others.

Water. 2022. 14(20).

doi: 10.3390/w14203240

The underwater internet of things (UloT) has emerged as a booming technology in today's digital world due to the enhancement of a wide range of underwater applications concerning ocean exploration, deep-sea monitoring, underwater surveillance, diver network monitoring, location and object tracking, etc. Generally, acoustic, infrared (IR), visible light (VL), radiofrequency (RF), and magnet induction (MI) are used as the medium of communication in order to transfer information among digitally linked underwater devices. However, each communication medium has its advantages and limitations: for example, the acoustic communication medium is suitable for long-range data transmission but has challenges such as narrow bandwidth, long delay, and high cost, etc., and the optical medium is suitable for short-range data transmission but has challenges such as high attenuation, and optical scattering due to water particles, etc. Furthermore, UloT devices are operated using batteries with limited capacity and high energy consumption; hence, energy consumption is considered as one of the most significant challenges in UloT networks. Therefore, to support reliable and energy-efficient communication in UloT networks, it is necessary to adopt robust energy optimization techniques for UloT networks. Hence, this paper focuses on identifying the various issues concerning energy optimization in the underwater internet of things and state-of-the-art contributions relevant to inducement techniques of energy optimization in the underwater internet of things; that provides a systematic literature review (SLR) on various power-saving and optimization techniques of UloT networks since 2010, along with core applications, and research gaps. Finally, future directions are proposed based on the analysis of various energy optimization issues and techniques of UloT networks. This research contributes much to the profit of researchers and developers to build smart, energy-efficient, auto-rechargeable, and battery-less communication systems for UloT networks.

keywords: underwater internet of things (UloT); energy optimization techniques; systematic literature review (SLR)

3-25 *Environmental Sciences & Ecology; Marine & Freshwater Biology*

Factors affecting the subsurface aragonite undersaturation layer in the Pacific Arctic region

Mo, Ahra., Kim, Dongseon., **Yang, Eun Jin.**, **Jung, Jinyoung.**, Ko, Young Ho., **Kang, Sung-Ho.**, **Cho, Kyoung-Ho.**, **Park, Keyhong.** and Kim, Tae-Wook.

Marine Pollution Bulletin. 2022. 183.

doi: 10.1016/j.marpolbul.2022.114060

This study evaluated interannual variation in the subsurface aragonite undersaturation zone ($\Omega_{Ar<1}$ layer) in the Pacific Arctic Ocean, using data from the 2016-2019 period. The upper boundary ($DEP_{\Omega<1}^{UB}$) of the $\Omega_{Ar<1}$ layer generally formed at a depth where the contribution of corrosive Pacific water was approximately 98%. The intensity of the Beaufort Gyre associated with freshwater accumulation mainly determined interannual variation in $DEP_{\Omega<1}^{UB}$, but the direction of its effect was opposite west and east of $\sim 166^\circ W$. The lower boundary ($DEP_{\Omega<1}^{LB}$) of the $\Omega_{Ar<1}$ layer was generally found at a depth range where equal contributions of Pacific and Atlantic water were expected. An Atlantic-origin cold saline water intrusion event in 2017 caused by an anomalous atmospheric circulation pattern significantly lifted the $DEP_{\Omega<1}^{LB}$, thus the thickness of the $\Omega_{Ar<1}$ layer decreased.

keywords: Arctic Ocean; Atmospheric circulation; Pacific-Arctic regions; Aragonite saturation; Beaufort gyre; Ocean acidification

3-26 *Fisheries*

Fluorescent and Luminescent Proteins Derived from Marine Organisms: Functions and Applications

Im, Sehyeok., **Hwang, Jisub.**, **Do, Hackwon.**, **Kim, Bo-Mi.**, **Lee, Sung Gu.** and **Lee, Jun Hyuck.**

Journal of Marine Life Science. 2022. 7(2): 74-85.

doi: 10.23005/ksmls.2022.7.2.74

Organisms constituting a large proportion of marine ecosystems, ranging from bacteria to fish, exhibit

fluorescence and bioluminescence. A variety of marine organisms utilize these biochemically generated light sources for feeding, reproduction, communication, and defense. Since the discovery of green fluorescent protein and the luciferin-luciferase system more than a century ago, numerous studies have been conducted to characterize their function and regulatory mechanism. The unique properties of fluorescent and bioluminescent proteins offer great potential for their use in a broad range of applications. This short review briefly describes the functions and characteristics of fluorescent and bioluminescent proteins, in addition to summarizing the recent status of their applications.

keywords: fluorescence; luminescence; marine; proteins

3-27 *Meteorology & Atmospheric Sciences; Oceanography*

Hydrography, circulation, and response to atmospheric forcing in the vicinity of the central Getz Ice Shelf, Amundsen Sea, Antarctica

Dundas, Var., Darelius, Elin., Daae, Kjersti., Steiger, Nadine., Nakayama, Yoshihiro. and **Kim, Tae-Wan.**

Ocean Science. 2022. 18(5): 1339-1359.

doi: 10.5194/os-18-1339-2022

Ice shelves in the Amundsen Sea are thinning rapidly as ocean currents bring warm water into the cavities beneath the floating ice. Although the reported melt rates for the Getz Ice Shelf are comparatively low for the region, its size makes it one of the largest freshwater sources around Antarctica, with potential consequences for, bottom water formation downstream, for example. Here, we use a 2-year-long novel mooring record (2016–2018) and 16-year-long regional model simulations to describe, for the first time, the hydrography and circulation in the vicinity of the ice front between Siple and Carney Island. We find that, throughout the mooring record, temperatures in the trough remain below 0.15°C, more than 1°C lower than in the neighboring Siple and Dotson Trough, and we observe a mean current (0.03 m s⁻¹) directed toward the ice shelf front. The variability in the heat transport toward the ice shelf appears to be governed by nonlocal ocean surface stress over the Amundsen Sea Polynya region, and northward to the continental shelf break, where strengthened westward ocean surface stress leads to increased southward flow at the mooring site. The model simulations suggest that the

heat content in the trough during the observed period was lower than normal, possibly owing to anomalously low summertime sea ice concentration and weak winds.

keywords: Amundsen Sea; Circulation; Getz Ice Shelf; Hydrography

3-28 *Science & Technology*

Ice front retreat reconfigures meltwater-driven gyres modulating ocean heat delivery to an Antarctic ice shelf

Yoon, Seung-Tae., **Lee, Won Sang.**, Nam, SungHyun., **Lee, Choon-Ki.**, **Yun, Sukyoung.**, Heywood, Karen, Boehme, Lars., Zheng, Yixi., Lee, Inhee., Choi, Yeon., Jenkins, Adrian., **Jin, Emilia Kyung.** and 4 others.

Nature Communications. 2022. 13(1).

doi: 10.1038/s41467-022-27968-8

Glacial melt can modify heat transport, and therefore ocean processes, associated with ice front retreat, as revealed by direct observations from the Pine Island Bay region of Antarctica. Pine Island Ice Shelf (PIIS) buttresses the Pine Island Glacier, the key contributor to sea-level rise. PIIS has thinned owing to ocean-driven melting, and its calving front has retreated, leading to buttressing loss. PIIS melting depends primarily on the thermocline variability in its front. Furthermore, local ocean circulation shifts adjust heat transport within Pine Island Bay (PIB), yet oceanic processes underlying the ice front retreat remain unclear. Here, we report a PIB double-gyre that moves with the PIIS calving front and hypothesise that it controls ocean heat input towards PIIS. Glacial melt generates cyclonic and anticyclonic gyres near and off PIIS, and meltwater outflows converge into the anticyclonic gyre with a deep-convex-downward thermocline. The double-gyre migrated eastward as the calving front retreated, placing the anticyclonic gyre over a shallow seafloor ridge, reducing the ocean heat input towards PIIS. Reconfigurations of meltwater-driven gyres associated with moving ice boundaries might be crucial in modulating ocean heat delivery to glacial ice.

3-29 *Environmental Sciences & Ecology; Marine & Freshwater Biology*

Identification of ventilated and submarine glacial meltwaters in the Amundsen Sea, Antarctica, using noble gases

Shin, DongYoub., Hahm, Doshik., **Kim, Tae-Wan., Rhee, Tae Siek., Lee, SangHoon., Park, Keyhong., Park, Jisoo.,** Kwon, Young Shin., **Kim, Mi Seon.** and Lee, Tongsup.

Frontiers in Marine Science. 2022. 9.

doi: 10.3389/fmars.2022.951471

To delineate the glacial meltwater distribution, we used five noble gases for optimum multiparameter analysis (OMPA) of the water masses in the Dotson-Getz Trough (DGT), Amundsen Sea. The increased number of tracers allowed us to define potential source waters at the surface, which have not been possible with a small set of tracers. The highest submarine meltwater (SMW) fraction (~0.6%) was present at the depth of ~450 m near the Dotson Ice Shelf. The SMW appeared to travel beyond the continental shelf break along an isopycnal layer. Air-equilibrated freshwater (up to 1.5%), presumably ventilated SMW (VMW) and surface melts, was present in the surface layer (<100 m). The distribution of SMW indicates that upwelled SMW, known as an important carrier of iron to the upper layer, amounts for 29% of the SMW in the DGT. The clear separation of VMW from SMW enabled partitioning of meltwater into locally-produced and upstream fractions and estimation of the basal melting of 53 – 94 Gt yr⁻¹ for the adjacent ice shelves, assuming that the SMW fractions represent accumulation since the previous Winter Water formation. The Meteoric Water (MET) fractions, consisting of SMW and VMW, comprised 24% of those derived from oxygen isotopes, indicating that the annual input from basal melting is far less than the inventory of meteoric water, represented by MET.

keywords: Amundsen Sea; Glacial meltwater; noble gases

Hirotsugu., **Jin, Young-Keun.,** Hachikubo, Akihiro., Hur, Jin., Ryu, Jong-Sik., Kang, Moo-Hee., **Jang, Kwangchul.,** Kida, Masato., Seo, Yongwon., Chen, Meilian., **Hong, Jong Kuk.** and 2 others.

Frontiers in Marine Science. 2022. 9.

doi: 10.3389/fmars.2022.944841

We investigated the pore fluid and methane-derived authigenic carbonate (MDAC) chemistry from the ARAON Mounds in the Chukchi Sea to reveal how methane (CH₄) seepage impacts their compositional and isotopic properties. During the ARA07C and ARA09C Expeditions, many *in situ* gas hydrates (GHs) and MDACs were found near the seafloor. The fluid chemistry has been considerably modified in association with the high CH₄ flux and its related byproducts (GHs and MDACs). Compared to Site ARA09C-St 08 (reference site), which displays a linear SO₄²⁻ downcore profile, the other sites (e.g., ARA07C-St 13, ARA07C-St 14, ARA09C-St 04, ARA09C-St 07, and ARA09C-St 12) that are found byproducts exhibit concave-up and/or kink type SO₄²⁻ profiles. The physical properties and fluid pathways in sediment columns have been altered by these byproducts, which prevents the steady state condition of the dissolved species through them. Consequently, chemical zones are separated between bearing and non-bearing byproducts intervals under non-steady state condition from the seafloor to the sulfate-methane transition (SMT). GH dissociation also significantly impacts pore fluid properties (e.g., low Cl⁻, enriched δD and δ¹⁸O). The upward CH₄ with depleted δ¹³C from the thermogenic origin affects the chemical signatures of MDACs. The enriched δ¹⁸O fluid from GH dissociation also influences the properties of MDACs. Thus, in the ARAON Mounds, the chemistry of the fluid and MDAC has significantly changed, most likely responding to the CH₄ flux and GH dissociation through geological time. Overall, our findings will improve the understanding and prediction of the pore fluid and MDAC chemistry in the Arctic Ocean related to CH₄ seepage by global climate change.

keywords: pore fluid; methane flux; gas hydrate; MDAC; ARAON Mounds

3-30 *Environmental Sciences & Ecology; Marine & Freshwater Biology*

Impact of High Methane Flux on the Properties of Pore Fluid and Methane-Derived Authigenic Carbonate in the ARAON Mounds, Chukchi Sea

Kim, Ji-Hoon., Park, Myong-Ho., Lee, Dong-Hun., Minami,

Impact of Sea Ice Melting on Summer Air-Sea CO₂ Exchange in the East Siberian Sea

Mo, Ahra., Yang, Eun Jin., Kang, Sung-Ho., Kim, Dongseon., Lee, Kitack., Ko, Young Ho., Kim, Kitae. and Kim, Tae-Wook.

Frontiers in Marine Science. 2022. 9.

doi: 10.3389/fmars.2022.766810

The role of sea ice melting on the air-sea CO₂ flux was investigated at two ice camps in the East Siberian Sea of the Arctic Ocean. On average, sea ice samples from the two ice camps had a total alkalinity (TA) of ~108 and ~31 μmol kg⁻¹ and a corresponding salinity of 1.39 and 0.36, respectively. A portion (18–23% as an average) of these sea ice TA values was estimated to exist in the sea ice with zero salinity, which indicates the excess TA was likely attributed to chemical (CaCO₃ formation and dissolution) and biological processes in the sea ice. The dilution by sea ice melting could increase the oceanic CO₂ uptake to 11–12 mmol m⁻² d⁻¹ over the next 21 days if the mixed layer depth and sea ice thickness were assumed to be 18.5 and 1.5 m, respectively. This role can be further enhanced by adding TA (including excess TA) from sea ice melting, but a simultaneous release of dissolved inorganic carbon (DIC) counteracts the effect of TA supply. In our study region, the additional impact of sea ice melting with close to unity TA:DIC ratio on air-sea CO₂ exchange was not significant.

keywords: Arctic Ocean; East Siberian Sea; sea ice melting; ikaite; total alkalinity

Import, export, and speciation of mercury in Kongsfjorden, Svalbard: Influences of glacier melt and river discharge

Kim, Jihee., Kwon, Sae Yun., Kim, Kitae. and Han, Seunghee.

Marine Pollution Bulletin. 2022. 179.

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The major sources and sinks of total mercury (THg) and methylmercury (MeHg) in Kongsfjorden were estimated based on spreadsheet-based ecological risk assessment for the fate of mercury (SERAfM). SERAFM

was parameterized and calibrated to fit Kongsfjorden using the physical properties of the fjord, runoff coefficients of Hg, transformation rate constants of Hg, partition coefficients of Hg, Hg loadings from freshwater, and solid balance parameters. The modeled Hg concentrations in the seawater matched with the measured concentrations, with a mean bias of 12% and a calibration error of 0.035. The mass budget showed that the major THg sources were tidal inflow and glacial runoff, while the major MeHg sources were tidal inflow and in situ methylation in shallow halocline water, which agreed with the distributions of THg and MeHg in seawater. The coupling of observation and fate modeling in Kongsfjorden provides a basic understanding of Hg cycles in the Arctic fjords.

keywords: Glacier; Kongsfjorden; Methylation; Methylmercury; SERAFM; Total mercury

Large-eddy simulations of the ice-shelf-ocean boundary layer near the ice front of Nansen Ice Shelf, Antarctica

Na, Ji Sung., Kim, Taekyun., Jin, Emilia Kyung., Yoon, Seung-Tae., Lee, Won Sang., Yun, Sukyoung. and Lee, Jiyeon.

Cryosphere. 2022. 16(9): 3451–3468.

doi: 10.5194/tc-16-3451-2022

Ice melting beneath Antarctic ice shelves is caused by heat transfer through the ice-shelf–ocean boundary layer (IOBL). However, our understanding of the fluid dynamics and thermohaline physics of the IOBL flow is poor. In this study, we utilize a large-eddy simulation (LES) model to investigate ocean dynamics and the role of turbulence within the IOBL flow near the ice front. To simulate the varying turbulence intensities, we imposed different theoretical profiles of the velocity. Far-field ocean conditions for the melting at the ice-shelf base and freezing at the sea surface were derived based on in situ observations of temperature and salinity near the ice front of the Nansen Ice Shelf. In terms of overturning features near the ice front, we validated the LES simulation results by comparing them with the in situ observational data. In the comparison of the velocity profiles to shipborne lowered acoustic Doppler current profiler (LADCP) data, the LES-derived strength of the overturning cells is similar to that obtained from the observational data.

Moreover, the vertical distribution of the simulated temperature and salinity, which were mainly determined by the positively buoyant meltwater and sea-ice formation, was also comparable to that of the observations. We conclude that the IOBL flow near the ice front and its contribution to the ocean dynamics can be realistically resolved using our proposed method. Based on validated 3D-LES results, we revealed that the main forces of ocean dynamics near the ice front are driven by positively buoyant meltwater, concentrated salinity at the sea surface, and outflowing momentum of the sub-ice-shelf plume. Moreover, in the strong-turbulence case, distinct features such as a higher basal melt rate (0.153 m yr^{-1}), weak upwelling of the positively buoyant ice-shelf water, and a higher sea-ice formation were observed, suggesting a relatively high speed current within the IOBL because of highly turbulent mixing. The findings of this study will contribute toward a deeper understanding of the complex IOBL-flow physics and its impact on the ocean dynamics near the ice front.

3-34 *Environmental Sciences & Ecology; Water Resources*

Marine Nitrogen Fixation and Phytoplankton Ecology

Lee, Sang Heon., Bhavya, Panthalil S. and **Kim, Bo Kyung.**

Water. 2022. 14(10).

doi: 10.3390/w14101638

Many oceans are currently undergoing rapid changes in environmental conditions such as warming temperature, acidic water condition, coastal hypoxia, etc. Obvious warming and acidification in various oceans, from polar oceans to tropical oceans, was well reported in the fifth Assessment Report (AR5) by the Intergovernmental Panel on Climate Change [1]. These climate-driven environmental changes could lead to dramatic alterations in the biology and ecology of phytoplankton as major primary producers and biogeochemical drivers and subsequently impact the growth and survival of other marine organisms [2–5]. Consequently, the entire marine ecosystem and global biogeochemical cycles would be very different from what we have now.

3-35 *Environmental Sciences & Ecology; Marine & Freshwater Biology*

Measurements and Spatial Distribution Simulation of Impact Pile Driving Underwater Noise Generated During the Construction of Offshore Wind Power Plant Off the Southwest Coast of Korea

Han, Dong-Gyun. and Choi, Jee Woong.

Frontiers in Marine Science. 2022. 8.

doi: 10.3389/fmars.2021.654991

Offshore wind power plants are under construction worldwide, and concerns about the adverse effects of underwater noise generated during their construction on the marine environment are increasing. As part of an environmental impact assessment, underwater noise generated by impact pile driving was measured during the construction of an offshore wind farm off the southwest coast of Korea. The sound exposure levels of impact pile driving noise were estimated as a function of distance and compared with those predicted by a damped cylindrical spreading model and broadband parabolic equation simulation. Source level at 1 m was estimated to be in a range of 183–184 dB re $1 \mu\text{Pa}^2\text{s}$ in the sound exposure level based on the model predictions and it tended to decrease by $21 \log r$ as the distance increased. Finally, the spatial distribution of impact pile driving noise was predicted. This result, if combined with noise-induced damage thresholds for marine life, may be used to assess the effects of wind farm construction on marine ecosystems.

keywords: impact pile driving; underwater ambient noise; sound propagation; acoustic modeling; marine environment

3-36 *Environmental Sciences & Ecology; Marine & Freshwater Biology*

Mercury and other trace elements distribution and profiling of microbial community in the surface sediments of East Siberian Sea

Chaudhary, Dhiraj Kumar., Karki, Hem Prakash., Bajagain, Rishikesh., Kim, Hwansuk., **Rhee, Tae Siek., Hong, Jong Kuk.** and 3 others.

Marine Pollution Bulletin. 2022. 185.

doi: 10.1016/j.marpolbul.2022.114319

In this study, total mercury (THg), methylmercury (MeHg), various trace elements, and microbial communities were measured in surface sediments of the East Siberian Sea (ESS). The results showed that the average values of THg and MeHg were 58.8 ± 15.21 $\mu\text{g/kg}$ and 0.50 ± 0.22 $\mu\text{g/kg}$, respectively. The notable levels of trace elements present in both surface sediment and porewater were Al, Fe, and Mn. The enrichment factor and geo-accumulation index analyses found that both natural phenomena and anthropogenic activities contributed to elevated concentrations of metals in the ESS. The redox proxy metals, pH, and SO_4^{2-} were the major factors influencing the THg and MeHg distributions. Microbial profiles were substantially affected by metals and other abiotic factors. Proteobacteria and Thaumarchaeota were the most abundant phyla. Overall, the findings presented here facilitate the understanding of the current status of metal contamination, its influencing factors, and metal-microbiota-interactions in ESS.

keywords: Arctic; Methylmercury; Microbial communities; Surface sediment; Total mercury; Trace elements

3-37 *Environmental Sciences & Ecology; Marine & Freshwater Biology*

Monthly and seasonal variations in the surface carbonate system and air-sea CO_2 flux of the Yellow Sea

Ko, Young Ho., Seok, Min-Woo., Jeong, Jin-Yong., Noh, Jae-Hoon., Jeong, Jongmin., **Mo, Ahra.** and Kim, Tae-Wook.

Marine Pollution Bulletin. 2022. 181.

doi: 10.1016/j.marpolbul.2022.113822

Surface carbonate chemistry in the Yellow Sea was investigated based on discrete seawater samples collected from 2017 to 2020 at the Socheongcho Ocean Research Station (S-ORS; 37.423°N , 124.738°E). Records of carbon parameters, including seawater CO_2 partial pressure ($p\text{CO}_2$), revealed considerable seasonal variations, with amplitudes comparable to those observed across the western part of the Yellow Sea. The study site acted as a modest sink ($-0.13 \text{ mol C m}^{-2} \text{ yr}^{-1}$) for atmospheric CO_2 . Biological processes (primary production and respiration) and physical conditions (temperature and degree of stratification) determined seawater $p\text{CO}_2$, which fluctuated on an intraseasonal timescale between oversaturated and undersaturated

with respect to atmospheric $p\text{CO}_2$. Variation in $p\text{CO}_2$ was significant in summer, depending on the biological carbon drawdown and tidal mixing-induced upwelling (increased $p\text{CO}_2$ up to $\sim 1000 \mu\text{atm}$). The intraseasonal variability in seawater $p\text{CO}_2$ may bias estimated air-sea CO_2 fluxes, if measurements with a coarser (seasonal) time resolution are used.

keywords: Yellow Sea; Coastal ocean; $p\text{CO}_2$; Air-sea CO_2 flux; Tidal mixing

3-38 *Oceanography*

Numerical Simulation of Ocean - Ice Shelf Interaction: Water Mass Circulation in the Terra Nova Bay, Antarctica

Kim, Taekyun., **Lee, Choon-Ki., Lee, Won Sang.,** Moon, Jae-Hong., **Jin, Emilia Kyung.** and **Na, Ji Sung.**

Ocean and Polar Research. 2023. 44(4): 269-285.

doi: 10.4217/opr.2022027

The interaction between ocean and ice shelf is a critical physical process in relation to water mass transformations and ice shelf melting/freezing at the ocean-ice interface. However, it remains challenging to thoroughly understand the process due to a lack of observational data with respect to ice shelf cavities. This is the first study to simulate the variability and circulation of water mass both overlying the continental shelf and underneath an ice shelf and an ice tongue in the Terra Nova Bay (TNB), East Antarctica. To explore the properties of water mass and circulation patterns in the TNB and the corresponding effects on sub ice shelf basal melting, we explicitly incorporate the dynamic-thermodynamic processes acting on the ice shelf in the Regional Ocean Modeling System. The simulated water mass formation and circulation in the TNB region agree well with previous studies. The model results show that the TNB circulation is dominated by the geostrophic currents driven by lateral density gradients induced by the releasing of brine or freshwater at the polynya of the TNB. Meanwhile, the circulation dynamics in the cavity under the Nansen Ice shelf (NIS) are different from those in the TNB. The gravity-driven bottom current induced by High Salinity Shelf Water (HSSW) formed at the TNB polynya flows towards the grounding line, and the buoyance-driven flow associated with glacial meltwater generated by the HSSW emerges from the cavity along the ice base. Both current systems

compose the thermohaline overturning circulation in the NIS cavity. This study estimates the NIS basal melting rate to be 0.98 m/a, which is comparable to the previously observed melt rate. However, the melting rate shows a significant variation in space and time.

keywords: Terra Nova Bay; ocean circulation model; ocean-ice shelf interaction; water mass and circulation

3-39 *Marine & Freshwater Biology; Oceanography*

Optimized Metavirome Analysis of Marine DNA Virus Communities for Taxonomic Profiling

Kim, Kang Eun., Jung, Seung Won., Park, Joon Sang., Kim, Hyun-Jung., Lee, Cholyoung., **Ha, Sun-Yong.** and Lee, Taek-Kyun.

Ocean Science Journal. 2022. 57(2): 259-268.

doi: 10.1007/s12601-022-00064-0

Recent advances in metavirome technology have provided new insights into viral diversity and function. The bioinformatic process of metavirome study is generally divided into two (or three) steps: assembly and taxonomic profiling including nucleotide alignment. Moreover, k-mer size and contig length are known to considerably affect the results of the assembly and consequently those of taxonomic profiling; however, the optimal k-mer size and contig length have not been established. In the present study, we analyzed marine virus DNA datasets with three different k-mer sizes using different assemblers: 1 k-mer (20) in the CLC Genomics Workbench, and 4 (21, 33, 55, and 77) and 5 (21, 33, 55, 77, and 99) k-mers in metaSPAdes. The use of large k-mers had the advantage of resolving more repeat regions, with higher N50 values and average contig lengths. The contig length helps reduce the error of continuous sequences and determine the number of viral operational taxonomic units. Our analysis suggested that 300 bp may be an appropriate minimum contig length, depending on the characteristics of viral samples. Based on the assembly result using metaSPAdes, we analyzed the DNA virus community using three taxonomic profiling tools: MG-RAST online server, the taxonomic profiling tools function in the CLC microbial module, and customized taxonomic assignment coding (CUTAXAC) using RStudio based on the BLASTn analysis. CUTAXAC showed the most diverse viral composition at the

family and species levels along with the highest Shannon diversity index and fastest analysis time.

keywords: Customized taxonomic assignment coding (CUTAXAC); Marine metavirome; Taxonomy profiling; Fast analysis time; High Shannon diversity

3-40 *Environmental Sciences & Ecology; Public, Environmental & Occupational Health*

Phytoplankton growth rates in the Amundsen Sea (Antarctica) during summer: The role of light

Lee, Youngju., Jung, Jinyoung., Kim, Tae Wan., Yang, Eun Jin. and Park, Jisoo.

Environmental Research. 2022. 207.

doi: 10.1016/j.envres.2021.112165

In the Amundsen Sea, significant global warming accelerates ice melt, and is consequently altering many ocean properties such as sea ice concentration, surface freshening, water column stratification, and underwater light properties. To examine the influence of light, which is one of the fundamental factors for phytoplankton growth, incubation experiments and field surveys were performed during the austral summer of 2016. In the incubation experiments, phytoplankton abundance and carbon biomass significantly increased with increasing light levels, probably indicating light limitation. Growth rates of the small pennates (mean 0.42 d^{-1}) increased most rapidly with an increase in light, followed by those of *Phaeocystis antarctica* (0.31 d^{-1}), and the large diatoms (0.16 d^{-1}). A short-term study during the field survey showed that phytoplankton distribution in the surface layer was likely controlled by different responses to light and the sinking rate of each species. These results suggest that the approach adopted by previous studies of explaining phytoplankton ecology as a characteristic of two major taxa, namely diatoms and *P. antarctica*, in the coastal Antarctic waters might cause errors owing to oversimplification and misunderstanding, since diatoms comprise several species that have different ecophysiological characteristics.

keywords: Phytoplankton; Growth rate; *Phaeocystis Antarctica*; Diatoms; Amundsen Sea; Light limitation

Phytoplankton photophysiology varies depending on nitrogen and light availability at the subsurface chlorophyll maximum in the northern Chukchi Sea

Ko, Eunho., Gorbunov, Maxim Y., Jung, Jinyoung., Lee, Youngju., Cho, Kyoung-Ho., Yang, Eun Jin. and Park, Jisoo.

Frontiers in Marine Science. 2022. 9.

doi: 10.3389/fmars.2022.979998

Vertical distributions of phytoplankton in the Arctic Ocean are characterized by a very narrow subsurface chlorophyll maximum (SCM) layer formed every summer after the sea ice retreats. Despite the prevalence of this narrow SCM layer, phytoplankton photosynthetic response to climate change remains to be elucidated. Here, we examined the photophysiological properties of phytoplankton in the SCM layer in the northern Chukchi Sea during the summers of 2015–2018. There was a significant difference in the SCM depth between the northwestern and northeastern Chukchi Sea determined by the distribution of Pacific Summer Water (PSW) around the SCM layer (34 ± 14 m vs. 49 ± 10 m, respectively). The maximum quantum yield of photochemistry in photosystem II (F_v/F_m) in the SCM phytoplankton was high ($F_v/F_m \geq 0.54$) and similar in both regions until 2016; however, since then, F_v/F_m in the northeastern Chukchi Sea has decreased by approximately 10%. This decrease was accompanied by a marked decrease in the fraction of microplankton, which are known to be susceptible to nutrient limitation. This result suggests a reduction in nitrogen availability in the SCM layer in the northeastern Chukchi Sea. Meanwhile, the maximum electron transfer rate (ETR^{max}) did not have a significant relationship with the nitrogen availability and phytoplankton community size structure in the SCM layer; however the improved light conditions (with an approximately two-fold increase in the relative ratio of surface PAR reaching the SCM layer) increased ETR^{max} by up to 30% in the SCM phytoplankton in the northwestern Chukchi Sea. Therefore, these results provide a better understanding of how changes in nitrogen and light availability could affect phytoplankton photosynthesis and primary production in the Arctic Ocean.

keywords: Arctic Ocean; Maximum electron transfer rate; Photochemical efficiency; Phytoplankton; nitrogen availability; subsurface chlorophyll maximum

Potential Short-Term Effects of Mine Tailings on Phytoplankton Assemblages in the Open Ocean

Choi, Dong Han., Yoo, Jangyeon., Yang, Wonseok., Noh, Jae Hoon., Lee, Yeonjung., Ra, Kongtae., Hyeong, Kiseong., Yoo, Chan Min. and Park, Jisoo.

Journal of Marine Science and Engineering. 2022. 10(8).

doi: 10.3390/jmse10081162

The disposal of mine tailings into the marine environment is considered an essential option to secure the economic efficiency of deep-sea mining, but it might adversely affects the ecosystem. To examine the potential impacts of tailing disposal from polymetallic nodules and polymetallic sulfide mines on phytoplankton communities, addition experiments of crushed fine particles into surface seawater were conducted in the open Indian Ocean and changes in chlorophyll a fluorescence and community composition were analyzed. The addition of tailings had serious adverse effects on phytoplankton fluorescence and photosynthetic activity, regardless of mine type. The adverse effects seemed to mainly be due to the physical properties of the mine tailings. These also showed discriminatory effects on phytoplankton, resulting in great changes in community composition. The results suggest that mine tailings could have significant adverse impacts on phytoplankton assemblages, but the degree of impact greatly varies depending on the phytoplankton groups. The discriminatory impacts would cause changes in biomass, community structure, and thus ecological function.

keywords: effects of mine tailing; polymetallic nodule; polymetallic sulfide; phytoplankton composition; chlorophyll fluorescence

Reconstruction of monthly fCO_2 distribution in the Ross Sea, Antarctica during 1998–2018 using machine learning technique and observational data sets

Mo, Ahra., Choi, Jung-Ok. and Park, Keyhong.

Data of Geology, Ecology, Oceanography, Space Science and Polar Science. 2022. 43:15–23.

doi: 10.22761/DJ2022.4.3.003

The ocean is a major reservoir of anthropogenic carbon dioxide, especially the Southern Ocean has been known to absorb 40% of the carbon dioxide emitted by human activity. The Ross Sea is one of the most productive regions in the Southern Ocean; however, its carbon dioxide absorption capacity has not been clearly evaluated yet. Because the Southern Ocean is geographically isolated from civilization and thus, its remoteness prevents making sufficient observations from proving reliable carbon dioxide sink strength estimates. Thus, in order to overcome the current spatial and temporal limitations of direct observations, the fugacity of carbon dioxide $f\text{CO}_2$ data was reproduced using a machine learning technique (i.e., random forest technique). The technique is a type of machine learning frequently used to reproduce marine environmental variations through training satellite data and modeled data as well as existing observational data. Furthermore, to reproduce more reliable $f\text{CO}_2$ estimates, in addition to marine environmental variables (i.e., sea surface temperature, sea ice concentration, and chlorophyll-*a* concentration), cloud cover, wind speed, and El Niño index were included in the machine learning procedure. In this study, we provide the past 21 years (1998 – 2018) of monthly spatial and temporal variation information of dissolved carbon dioxide in the Ross Sea, Antarctica.

keywords: Ross Sea; machine learning; carbon dioxide; random forest

Korea with previous datasets covering the Yellow Sea, East Sea, northern South China Sea, and southeast coast of South Korea. In general, offshore waters absorb atmospheric CO_2 ; however, most of the collected water samples show aragonite oversaturation. On the southeast coast, the aragonite saturation state was significantly affected by river discharge and associated variables, such as freshwater input with nutrients, seasonal stratification, biological carbon fixation, and bacterial remineralization. In summer, hypoxia and mixing with relatively acidic freshwater made the Jinhae and Gwangyang Bays undersaturated with respect to aragonite, possibly threatening marine organisms with CaCO_3 shells. However, widespread aragonite undersaturation was not observed on the west coast, which receives considerable river water discharge. In addition, occasional upwelling events may have worsened the ocean acidification in the southwestern part of the East Sea. These results highlight the importance of investigating site-specific ocean acidification processes in coastal waters. Along with the above-mentioned seasonal factors, the dissolution of atmospheric CO_2 and the deposition of atmospheric acidic substances will continue to reduce the aragonite saturation state in Korean waters. To protect marine ecosystems and resources, an ocean acidification monitoring program should be established for Korean waters.

keywords: ocean acidification; air-sea exchange of CO_2 ; ocean carbon cycles

3-44 *Environmental Sciences & Ecology*

A Review on Ocean Acidification and Factors Affecting It in Korean Waters

Kim, Tae-Wook., Kim, Dongseon., Park, Geun-Ha., Ko, Young Ho. and **Mo, Ahra.**

The Journal of The Korean Earth Science Society. 2022. 43(1): 91-109.

doi: 10.5467/JKESS.2022.43.1.91

The ocean is a significant sink for atmospheric anthropogenic CO_2 , absorbing one-third of the total CO_2 emitted by human activities. In return, oceans have experienced significant declines in seawater pH and the aragonite saturation state also called ocean acidification. This study evaluates the distribution of aragonite saturation state, an indicator to assess the potential threat from ocean acidification, by combining newly obtained data from the west coast of South

3-45 *Environmental Sciences & Ecology; Marine & Freshwater Biology*

Role of Aerosols in Spring Blooms in the Central Yellow Sea During the COVID-19 Lockdown by China

Baek, Ji-Yeon., **Park, Jinku.** and 5 others.

Frontiers in Marine Science. 2022. 9.

doi: 10.3389/fmars.2022.911819

Reduced amounts of aerosols blowing into the Yellow Sea (YS), owing to the temporary lockdown of factories in China during COVID-19, resulted in a 15% decrease in spring chlorophyll-*a* concentration (CHL) in March 2020 compared to its mean March values from 2003 to 2021. Particularly, the effect of land-based AOD is insignificant compared with that of atmospheric aerosols flowing into the YS, as indicated by the

currents and wind directions. Hence, the main objective of this study was to understand the relationship between atmospheric aerosols and CHL by quantitatively considering relevant environmental changes using a Random Forest (RF) algorithm. Various input physical forcing variables to RF were employed, including aerosol optical depth (AOD), sea surface temperature (SST), mixed layer depth (MLD), wind divergence (WD), and total precipitation (TP). From the RF-based analysis, we estimated the relative contribution of each physical forcing variable to the difference in CHL during and after the COVID-19 lockdown period. The sensitivity of the RF model to changes in aerosol levels indicated positive effects of increased amounts of aerosols during spring blooms. Additionally, we calculated the quantitative contribution of aerosols to CHL changes. When SST was warmer and TP was lower than their climatology in March 2020, CHL increased by 0.22 mg m^{-3} and 0.02 mg m^{-3} , respectively. Conversely, when MLD became shallower and AOD was lower than their climatology, CHL decreased as much as 0.01 mg m^{-3} and 0.20 mg m^{-3} . Variations in WD caused no significant change in CHL. Overall, the specific estimations for reduced spring blooms were caused by a reduction in aerosols during the COVID-19 lockdown period. Furthermore, the RF developed in this study can be used to examine CHL changes and the relative role of significant environmental changes in biological blooms in the ocean for any normal year.

keywords: COVID-19 lockdown; aerosol; spring bloom; random forest; Central Yellow Sea

3-46 *Chemistry; Oceanography*

The role of the Dotson Ice Shelf and Circumpolar Deep Water as driver and source of dissolved and particulate iron and manganese in the Amundsen Sea polynya, Southern Ocean

Van Manen, Mathijs., Aoki, Shigeru., Brussaard, Corina P. D., Conway, Tim M., Eich, Charlotte., Gerringa, Loes J. A., Jung, Jinyoung., Kim, Tae Wan., Lee, SangHoon., Lee, Youngju. and 4 others.

Marine Chemistry. 2022. 246.

doi: 10.1016/j.marchem.2022.104161

Coastal areas around Antarctica such as the Amundsen Sea are important sources of trace metals and

biological hotspots, but are also experiencing the effects of climate change, including the rapid thinning of ice sheets. In the central Amundsen Sea Polynya (ASP), both bio-essential dissolved Fe (DFe) and dissolved Mn (DMn) were found to be depleted at the surface, indicating substantial biological uptake and/or precipitation. Close to the Dotson Ice Shelf (DIS) there were elevated surface concentrations of DMn ($>3 \text{ nM}$) but surprisingly not for DFe ($<0.3 \text{ nM}$). While Fe-binding ligand data suggests that ligands were abundant near the DIS, these were most likely not strong enough to outcompete scavenging and thus increase DFe substantially in the outflow. In contrast to the dissolved phase, particulate Fe (PFe) and Mn (PMn) concentrations (both labile and refractory fractions) were elevated over the entire water column close to the DIS and partly in the central ASP. We hypothesize that DFe was released from the DIS and immediately established an equilibrium with the labile particulate Fe (L-PFe) pool, via (reversible) scavenging, as indicated by a positive correlation between L-PFe and DFe in the outflow. This scavenging results in relatively low DFe concentrations, but the pool of labile PFe likely buffers the DFe pool when DFe is decreasing, e.g. due to uptake by phytoplankton. The DFe distribution also shows that inflowing modified circumpolar deep water (mCDW) and benthic sediments are clear and important sources for both DFe and DMn in the ASP. Refractory Fe and Mn likely have a lithogenic source, whereas the labile fractions are mostly biogenic in surface waters, and authigenic in deep waters ($>100 \text{ m}$ depth). We compared different uptake ratios, underlining that uptake ratio estimates do not necessarily capture natural variability and it is likely better to use a range of values. In the future, climate change may increase the heat flux of mCDW and thereby the melting of the DIS. This will most likely cause an increased input of Fe and Mn into the ASP, which may fuel increased levels of primary productivity in the ASP.

keywords: GEOTRACES; Trace metal; Southern Ocean; Iron limitation; Biogeochemistry

3-47 *Environmental Sciences & Ecology; Marine & Freshwater Biology*

Roles of Atmosphere Thermodynamic and Ocean Dynamic Processes on the Upward Trend of Summer Marine Heatwaves Occurrence in East Asian Marginal Seas

Lee, Sang-Bin., Yeh, Sang-Wook., Lee, Jeong-Seo., Park,

Young-Gyu., Kwon, Minho., **Jun, Sang-Yoon.** and Jo, Hyun-Su.

Frontiers in Marine Science. 2022. 9.

doi: 10.3389/fmars.2022.889500

By analyzing the European Centre for Medium-Range Weather Forecasts reanalysis version 5 (ERA5) dataset, we found increased frequency of marine heatwaves (MHWs) in East Asian marginal seas (EAMS) during the boreal summer (June–July–August) in the recent past. To examine which processes are responsible for the upward trend of MHW occurrence, we performed three numerical simulations using Modular Ocean Model version 5 (MOM5) forced by ERA5 dataset. The first experiment used historical atmospheric variables to force the MOM5 for 1982 to 2020, which reasonably simulated the upward trend of MHWs as well as its dominant variability in terms of temporal and spatial structure in EAMS. The second (third) experiment is the same as in the first except that the atmosphere variables used to force the MOM5 consisted of thermodynamic (dynamic) variables only. The upward trend of MHW occurrence in EAMS is simulated in the first and the second experiment only. We argue that the atmosphere thermodynamic processes, in particular, the shortwave radiative forcing, play a key role in inducing the upward trend of MHW occurrence in EAMS during the boreal summer compared to the ocean dynamic processes.

keywords: marine heatwave; ocean general circulation model; sea surface temperature

availability caused by Arctic warming. Subsequently, under-ice blooms (UIBs) are being recognized as an important phenomenon from the traditional perspective. However, the role of sea-ice algae in UIBs is still unknown due to the limited availability of continuous observations. We analyzed data on primary producer-derived lipid biomarkers from sinking particles collected over 1 year using time-series sediment traps on the East Siberian Sea and Chukchi Sea slopes. Based on the seasonal changes in sympagic organic carbon derived from the data of the ice proxy (IP₂₅) flux and pelagic biomarkers, such as highly branched isoprenoid trienes, epi-brassicasterol and dinosterol, a UIB was identified in summer 2018 on the East Siberian Sea slope. Compared to the nutrient distribution on the Chukchi Sea slope, the UIB on the East Siberian Sea slope might have been triggered by the nutrient supply. The estimated flux-weighted mean sympagic organic carbon value measured during the UIB period (May–August) was 1.04 mg m⁻² d⁻¹ on the East Siberian Sea slope, approximately five times greater than recorded that on the Chukchi Sea slope (0.23 mg m⁻² d⁻¹) during the same period. Our findings suggest that the importance of sea-ice algae as primary producers has increased as the UIB phenomenon has become more important in the Arctic Ocean and that sea-ice environments face changes due to Arctic warming.

keywords: Chukchi Sea; East Siberian Sea; Highly branched isoprenoids; IP₂₅; sediment trap; under-ice bloom

3-48 Oceanography

Seasonal Flux of Ice-Related Organic Matter During Under-Ice Blooms in the Western Arctic Ocean Revealed by Algal Lipid Biomarkers

Gal, Jong-Ku., Ha, Sun-Yong., Park, Jisoo., Shin, Kyung-Hoon., Kim, Dongseon., Kim, Nan-Young., **Kang, Sung-Ho.** and **Yang, Eun Jin.**

Journal of Geophysical Research-Oceans. 2022. 127(2).

doi: 10.1029/2021jc017914

Satellite observations and modeling data have suggested a significant increase in net primary production in the Arctic Ocean over the last decade due to retreating sea ice and the development of light

3-49 Science & Technology

Seasonal variability of ocean circulation near the Dotson Ice Shelf, Antarctica

Yang, Heewon., Kim, Tae-Wan., Dutrieux, Pierre., Wahlin, A. K., Jenkins, Adrian., **Cho, Kyoung-Ho., Park, Taewook.** and **Lee, SangHoon.**

Nature Communications. 2022. 13(1).

doi: 10.1038/s41467-022-28751-5

Recent rapid thinning of West Antarctic ice shelves are believed to be caused by intrusions of warm deep water that induce basal melting and seaward meltwater export. This study uses data from three bottom-mounted mooring arrays to show seasonal variability and local forcing for the currents moving into and out of the Dotson ice shelf cavity. A

southward flow of warm, salty water had maximum current velocities along the eastern channel slope, while northward outflows of freshened ice shelf meltwater spread at intermediate depth above the western slope. The inflow correlated with the local ocean surface stress curl. At the western slope, meltwater outflows followed the warm influx along the eastern slope with a similar to ~2-3 month delay. Ocean circulation near Dotson Ice Shelf, affected by sea ice distribution and wind, appears to significantly control the inflow of warm water and subsequent ice shelf melting on seasonal time-scales.

keywords: Dotson Ice shelf; Meltwater; mCDW; ocean circulation

hyperboreus were abundant. The distributions and structures of mesozooplankton communities indicated variability over large spatial scales in the western Arctic waters because of variations in multiple factors, such as water temperature, salinity, and sea ice; however, geographical effects cannot be ignored even during alterations in the physical properties. Our results suggest that these variable patterns of mesozooplankton communities fluctuate horizontally from south to north as warming progresses on a regional bathymetric basis, and can be used to infer the fate of mesozooplankton communities in the study area.

keywords: Arctic Ocean; Climate change; Community structure; Pelagic ecosystems; Zooplankton

3-50 Oceanography

Spatial and Interannual Patterns of Epipelagic Summer Mesozooplankton Community Structures in the Western Arctic Ocean in 2016-2020

Kim, Jee-Hoon., La, Hyoung Sul., Cho, Kyoung-Ho., Jung, Jinyoung., Kang, Sung-Ho., Lee, Kanghyun. and Yang, Eun Jin.

Journal of Geophysical Research-Oceans. 2022. 127(3).
doi: 10.1029/2021jc018074

Mesozooplankton play a crucial role as primary or secondary consumers in Arctic ecosystems and are sensitive indicators of environmental changes. This research is the first comprehensive Arctic zooplankton study covering the area ranging from the southern Chukchi Sea (SCS) and the northern Chukchi Sea (NCS) to the East Siberian Sea (ESS). Mesozooplankton samples were collected at 151 stations in the western Arctic Ocean each August from 2016 to 2020. The mesozooplankton abundance of the study area ranged from 9 to 6,172 ind. m⁻³, and the predominant group was copepods at 7–3,866 ind. m⁻³, of which *Pseudocalanus* spp. and *Calanus glacialis* were the most abundant copepods. In the SCS, small copepods and meroplankton, such as *Pseudocalanus* spp., Cirripedia larvae, Echinodermata larvae, and *Centropages abdominalis* were the predominant taxa. Especially in 2019, *C. abdominalis* dominated over meroplankton when water temperatures were high (maximum 12.5°C; sea surface temperature, SST). In the NCS and ESS, *C. glacialis*, *Pseudocalanus* spp., *Metridia longa*, *Oithona similis*, *Parasagitta elegans*, and *Calanus*

3-51 Environmental Sciences & Ecology; Public, Environmental & Occupational Health

Spatial distribution and origin of organic matters in an Arctic fjord system based on lipid biomarkers (n-alkanes and sterols)

Gal, Jong-Ku., Kim, Bo Kyung., Joo, Hyoung Min., Shim, Chorom., Lee, Boyeon., Kim, Il-Nam., Jung, Jinyoung., Shin, Kyung-Hoon. and Ha, Sun-Yong.

Environmental Research. 2022. 205.
doi: 10.1016/j.envres.2021.112469

The concentration of n-alkanes (C₁₇–C₃₅) and sterols in marine particulate matter were investigated to trace the origin of organic carbon in Kongsfjorden in early spring (April). The spatial distributions of environmental factors (seawater temperature, salinity, density, turbidity, chlorophyll *a* (chl. *a*) and particulate organic carbon (POC) concentrations) and the cell density of phytoplankton differed between the inner and outer fjord regions. In addition, brassicasterol, diatom biomarker, showed a high concentration in the outer fjord and positive correlations with the chl. *a* and POC concentrations in the water column. In contrast, some sterols originating from terrestrial organic matter (OM), such as stigmasterol and campesterol, showed relatively higher concentrations in the inner fjord than in the outer fjord. Based on the distance-based redundancy analysis (db-RDA) result, the distributions of organic compounds are predominantly controlled by the water density and the POC and chl. *a* concentrations, and these distributions allowed us to divide the inner and outer fjord regions. However, the

hierarchical clustering of principal components (HCPC) results obtained based on principal component analysis (PCA) using lipid biomarkers (C_{17} – C_{35} alkanes and sterols) and environmental factors indicated that the clusters were distinguished by surface (0 m) and subsurface (>4 m) seawater samples rather than by any regional division. Notably, the concentration of relatively short-chain alkanes (average chain length (ACL): 24.6 ± 3.7) without a carbon preference for odd numbers (carbon preference index (CPI): 0.97 ± 0.11) in the sea surface layer was significantly higher than that of subsurface seawater (ACL: 31.1 ± 0.5 and CPI: 1.06 ± 0.03) in the early spring. This suggests the potential of these compounds as indicators for tidewater glacier-derived OM and freshwater input by snow melt into the fjord system. Hence, these results demonstrate that the distributions of lipid biomarkers in the water column possibly provide important information for a comprehensive understanding of the origin and transport of OM in an Arctic fjord.

keywords: Sterols; Lipid biomarkers; Tidewater glacier; Kongsfjorden; N-alkanes

3-52 Oceanography

Spatial Distributions of Riverine and Marine Dissolved Organic Carbon in the Western Arctic Ocean: Results From the 2018 Korean Expedition

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

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doi: 10.1029/2021jc017718

Seasonal primary production and river discharge increases in the Arctic Ocean exert a significant influence on the dissolved organic carbon (DOC) cycle. To improve our knowledge of the spatial heterogeneity of DOC source and concentration in the rapidly changing Arctic Ocean, we investigated the distributions of riverine and marine DOC in the western Arctic Ocean during the summer of 2018. Although the surface bulk DOC concentration indicated no clear distinction in its distribution between the Chukchi Borderland (CBL)/northern Chukchi Sea (NCS) and East Siberian Sea (ESS)/Mendeleev Ridge (MR) regions, the estimated riverine DOC concentration ($28 \pm 4.2 \mu\text{M C}$) and its contribution ($40 \pm 5.7\%$) in the surface layer of the CBL/NCS region

were higher than those ($19 \pm 5.6 \mu\text{M C}$ and $26 \pm 8.5\%$) in the ESS/MR region, which was attributed to the accumulation of freshwater, strong stratification, and a longer residence time in the CBL/NCS region. In contrast, although marine DOC was the dominant DOC component in both the CBL/NCS and ESS/MR regions, the higher marine DOC concentration ($54 \pm 8.1 \mu\text{M C}$) and its contribution ($73 \pm 8.2\%$) in the East Siberian shelf/slope region were consistent with high bacterial abundance, which was associated with extremely high surface phytoplankton blooms sustained by nutrient supply from the deep layer, suggesting that the supply of bioavailable DOC resulted in active bacterial activities. Overall, the spatial differences in water properties between the two regions had large influences on the regional distributions of riverine and marine DOC.

3-53 Environmental Sciences & Ecology; Public, Environmental & Occupational Health

Spatial dynamics of active microeukaryotes along a latitudinal gradient: Diversity, assembly process, and co-occurrence relationships

Xu, Dapeng., Kong, Hejun., **Yang, Eun-Jin.**, Wang, Ying., Li, Xinran., Sun, Ping., Jiao, Nianzhi., **Lee, Youngju., Jung, Jinyoung.** and **Cho, Kyoung-Ho.**

Environmental Research. 2022. 212.

doi: 10.1016/j.envres.2022.113234

Recent global warming is profoundly and increasingly influencing the Arctic ecosystem. Understanding how microeukaryote communities respond to changes in the Arctic Ocean is crucial for understanding their roles in the biogeochemical cycles of nutrients and elements. Between July 22 and August 19, 2016, during cruise ARA07, seawater samples were collected along a latitudinal transect extending from the East Sea of Korea to the central Arctic Ocean. Environmental RNA was extracted and the V4 hypervariable regions of the reverse transcribed SSU rRNA were amplified. The sequences generated by high throughput sequencing were clustered into zero-radius OTUs (ZOTUs), and the taxonomic identities of each ZOTU were assigned using SINTAX against the PR2 database. Thus, the diversity, community composition, and co-occurrence networks of size fractionated microeukaryotes were revealed. The present study found: 1) the alpha

diversity of pico- and nano-sized microeukaryotes showed a latitudinal diversity gradient; 2) three distinct communities were identified, *i.e.*, the Leg-A, Leg-B surface, and Leg-B subsurface chlorophyll a maximum (SCM) groups; 3) distinct network structure and composition were found in the three groups; and 4) water temperature was identified as the primary factor driving both the alpha and beta diversities of microeukaryotes. This study conducted a comprehensive and systematic survey of active microeukaryotes along a latitudinal gradient, elucidated the diversity, community composition, co-occurrence relationships, and community assembly processes among major microeukaryote assemblages, and will help shed more light on our understanding of the responses of microeukaryote communities to the changing Arctic Ocean.

keywords: SSU rRNA; Northwest Pacific ocean; Arctic; Protist; Latitudinal diversity gradient (LDG)

3-54 *Plant Sciences; Marine & Freshwater Biology*

Statistical optimization of phytol and polyunsaturated fatty acid production in the Antarctic microalga *Micractinium variable* KSF0031

Kim, Eun Jae., Chae, Hyunsik., Koo, Man Hyung., Yu, Jihyeon., Kim, Hyunjoong., Cho, Sung Mi., Hong, Kwang Won., Lee, Joo Young., Youn, Ui Joung., Kim, Sanghee., Choi, Han-Gu. and Han, Se Jong.

Algae. 2022. 37(2): 175-183.

doi: 10.4490/algae.2022.37.4.1

Polar microorganisms produce physiologically active substances to adapt to harsh environments, and these substances can be used as biomedical compounds. The green microalga *Micractinium variable* KSF0031, which was isolated from Antarctica, produced phytol, a natural antimicrobial agent. Furthermore, several polyunsaturated fatty acids (PUFAs), including omega-3, exhibit antioxidant properties. Here statistical methods (Plackett-Burman design and Box-Behnken design) were used to optimize the culture medium of KSF0031 to improve biomass production, and K_2HPO_4 , $MgSO_4 \cdot 7H_2O$, and ammonium ferric citrate green (AFCg) were selected as significant components of the culture medium. Changes in the concentration of K_2HPO_4 and $MgSO_4 \cdot 7H_2O$ as positive factors and AFCg as a negative factor affected cell growth to a

remarkable degree. The biomass production in a 100 L culture using the optimized medium for 24 d at 18°C was improved by 37.5% compared to that obtained using the original BG-11 medium. The quantities of PUFAs and phytol obtained were 13 mg g⁻¹ dry cell weight (DCW) and 10.98 mg g⁻¹ DCW, which represent improved yields of 11.70% and 48.78%, respectively. The results of this study could contribute to an improved production of phytol and fatty acids from Antarctic microalgae in the biomedical industry.

keywords: Antarctic algae; growth medium optimization; *Micractinium variable*; phytol; polyunsaturated fatty acids

3-55 *Environmental Sciences & Ecology; Marine & Freshwater Biology*

Summer net community production in the northern Chukchi Sea: Comparison between 2017 and 2020

Kwon, Soyeon., Lee, Inhee., Park, Keyhong., Cho, Kyoung-Ho., Jung, Jinyoung., Park, Taewook., Lee, Youngju. and 3 others.

Frontiers in Marine Science. 2022. 9.

doi: 10.3389/fmars.2022.1050791

The Arctic Ocean environment is drastically changing because of global warming. Although warming-induced processes, such as the decrease in sea-ice extent and freshening of the surface layer, have the potential to alter primary production, the changes that will likely occur in their production and their mechanisms are still poorly understood. To assess the potential changes in net community production, which is a measure of biological carbon pump, in response to climate change, we observed the O_2/Ar at the surface of the northern Chukchi Sea in the summers of 2017 and 2020. The net community production (NCP) estimates that we derived from O_2/Ar measurements were largely in the range of 1 – 11 mmol O_2 m⁻² d⁻¹ in the northern Chukchi and Beaufort Seas, close to the lower bounds of the values in the global oceans. The average NCP of 1.5 ± 1.7 mmol O_2 m⁻² d⁻¹ in 2020 was substantially lower than 7.1 ± 7.4 mmol O_2 m⁻² d⁻¹ in 2017, with the most pronounced decrease occurring in the ice-free region of the northern Chukchi Sea; the NCP of the ice-free region in 2020 was only 12% of that in 2017. The decrease in NCP in 2020 was accompanied by a lower salinity of > 2, which resulted in shallower mixed layer depths and stronger stratification. We speculated that

the anomalously low pressure near the east Russian coast and the lack of strong winds contributed to the strong stratification in 2020. With a continuing decrease in the extent of sea ice, the northern Chukchi Sea will likely experience earlier phytoplankton blooms and nitrate exhaustion. Unless winds blow strong enough to break the stratification, the biological pump in late summer is likely to remain weak.

keywords: Biological pump; Chukchi Sea; Net Community Production; Nitrate Flux; O₂/Ar

3-56 Fisheries

Target strength of Antarctic krill and ice krill using the SDWBA model

Son, Wuju., La, Hyoung Sul. and 2 others.

Journal of the Korean Society of Fisheries and Ocean Technology. 2022. 58(4): 352-358.

doi: 10.3796/KSFOT.2022.58.4.352

We explored the frequency response of krill target strength (TS) to understand the Antarctic krill (*Euphausia superba*) and ice krill (*Euphausia crystallorophias*) using the stochastic distorted-wave Born approximation (SDWBA) model. The results showed that the distribution of orientation and the fatness factor could significantly impact on the frequency response of TS. Krill TS is clearly depended on acoustic properties, which could affect to estimate the biomass of two krill species. The results provide insight into the importance of understanding TS variation to estimate the Antarctic krill and ice krill biomass, and their ecology related to the environmental features in the Southern Ocean.

keywords: Antarctic krill; Ice krill; SDWBA model; Target strength

3-57 Fisheries

Target strength of juvenile Antarctic silverfish (*Pleuragramma antarcticum*)

Lee, Sara., Oh,woo-sepk., La, Hyoung Sul., Son, Wuju., Kim, Jeong-Hoon. and Kyounghoon, Lee

Journal of the Korean Society of Fisheries and Ocean Technology. 2022. 58(4): 345-351.

doi: 10.3796/KSFOT.2022.58.4.345

In this study, the target strength for multi-frequency (38

kHz, 120 kHz, 200 kHz) of juvenile silverfish (*Pleuragramma antarcticum*) was estimated using by the KRM (Kirchhoff-ray mode) model. The body shape of the silverfish was described by a picture and the body length of nine individuals ranged in 1.8 cm to 8.8 cm. The maximum TS_{cm} according to the total length for the constant term (b20) was -92.93 dB at 38 kHz, -86.63 dB at 120 kHz, and -85.89 dB at 200 kHz, respectively. The averaged TS_{cm} according to total length for the constant term (b20) was -100.0 dB at 38 kHz, -93.0 dB at 120 kHz, and -106.9 dB at 200 kHz, respectively.

keywords: Antarctic silverfish; Juvenile fish; Kirchhoff-ray mode model; Target strength

3-58 Environmental Sciences & Ecology; Marine & Freshwater Biology; Microbiology

Temporal Variations Rather than Long-Term Warming Control Extracellular Enzyme Activities and Microbial Community Structures in the High Arctic Soil

Yun, Jeongeun., Jung, Ji Young., Kwon, Min Jung., Seo, Juyoung., Nam, Sungjin., Lee, Yoo Kyung. and Kang, Hojeong.

Microbial Ecology. 2022. 84(1): 168-181.

doi: 10.1007/s00248-021-01859-9

In Arctic soils, warming accelerates decomposition of organic matter and increases emission of greenhouse gases (GHGs), contributing to a positive feedback to climate change. Although microorganisms play a key role in the processes between decomposition of organic matter and GHGs emission, the effects of warming on temporal responses of microbial activity are still elusive. In this study, treatments of warming and precipitation were conducted from 2012 to 2018 in Cambridge Bay, Canada. Soils of organic and mineral layers were collected monthly from June to September in 2018 and analyzed for extracellular enzyme activities and bacterial community structures. The activity of hydrolases was the highest in June and decreased thereafter over summer in both organic and mineral layers. Bacterial community structures changed gradually over summer, and the responses were distinct depending on soil layers and environmental factors; water content and soil temperature affected the shift of bacterial community structures in both layers, whereas bacterial abundance, dissolved organic carbon, and inorganic nitrogen did so in the organic

layer only. The activity of hydrolases and bacterial community structures did not differ significantly among treatments but among months. Our results demonstrate that temporal variations may control extracellular enzyme activities and microbial community structure rather than the small effect of warming over a long period in high Arctic soil. Although the effects of the treatments on microbial activity were minor, our study provides insight that microbial activity may increase due to an increase in carbon availability, if the growing season is prolonged in the Arctic.

keywords: Arctic; Tundra; Extracellular enzyme activity; Bacterial community structure; Warming; Temporal variations

3-59 Fisheries

The first attempt of utilization of a wideband autonomous acoustic system and its general knowledge on analyzing the wideband acoustic data

KANG, Myounghee., CHO, Youn-Hyoung., **LA, Hyoung sul, SON, Wuju.** and 3 others.

J Korean Soc Fish Ocean Technol, 2022. 58(2): 130-140.
doi: 10.3796/KSFOT.2022.58.2.130

Recently, wideband acoustic technology has been introduced and started to be used in fisheries acoustic surveys in various waters worldwide. Wideband acoustic data provides high vertical resolution, high signal-to-noise ratio and continuous frequency characteristics over a wide frequency range for species identification. In this study, the main characteristics of wideband acoustic systems were elaborated, and a general methodology for wideband acoustic data analysis was presented using data collected in frequency modulation mode for the first time in Republic of Korea. In particular, this study described the data recording method using the mission planner of the wideband autonomous acoustic system, wideband acoustic data signal processing, calibration and the wideband frequency response graph. Since wideband acoustic systems are currently installed on many training and research vessels, it is expected that the results of this study can be used as basic knowledge for fisheries acoustic research using the state-of-the-art system.

keywords: Wideband; Autonomous echosounder; Frequency modulation; Wideband frequency response

3-60 Marine & Freshwater Biology; Oceanography

Tight association between microbial eukaryote and giant virus communities in the Arctic Ocean

Xia, Jun., Kameyama, Sohiko., Proding, Florian., Yoshida, Takashi., **Cho, Kyoung-Ho., Jung, Jinyoung., Kang, Sung-Ho., Yang, Eun-Jin.** and 2 others.

Limnology and Oceanography. 2022. 67(6): 1343-1356.
doi: 10.1002/lno.12086

Viruses are important regulatory factors of the marine microbial community including microeukaryotes. However, little is known about their role in the northern Chukchi Sea in the Arctic basin, which has oligotrophic conditions in summer. To clarify the link between microbial eukaryotic communities and viruses as well as environmental conditions, we investigated the community structures of microeukaryotes (from 3 to 144 μm and from 0.23 μm size bio-particles collected from seawater) and *Imitervirales* (from 0.23 μm size bio-particles collected from seawater), a dominant group of viruses infecting marine microeukaryotes. To the best of our knowledge, no study has investigated both *Imitervirales* and eukaryotic communities in the Arctic Ocean. Surface water samples were collected at 21 ocean stations located in the northeastern Chukchi Sea and an adjacent area outside the Beaufort Gyre (Adjacent Sea), and at two melt ponds on sea ice in the summer of 2018. At the ocean stations, nutrient concentrations were low in most of the locations, except the shelf in the adjacent sea. The community variations were significantly correlated between eukaryotes and *Imitervirales*, even within the northeastern Chukchi Sea characterized by relatively homogeneous environmental conditions. The association of the eukaryotic community with the viral community was stronger than that with geographical and physicochemical environmental factors. These results suggest that *Imitervirales* actively infect their hosts even in the cold and oligotrophic seawater in the Arctic Ocean.

3-61 *Environmental Sciences & Ecology; Geology; Oceanography*
Tintinnid ciliates (marine microzooplankton) of the Ross Sea

Dolan, John R., **Son, Wuju., La, Hyoung Sul., Park, Jisoo.** and **Yang, Eun Jin.**

Polar Research.2022.VOL. 41

doi: 10.33265/polar.v41.8382

For the Ross Sea, the only Marine Protected Area in Antarctica, available data on the tintinnid ciliates of the marine microzooplankton are mostly limited to nearshore waters near Terra Nova Bay or the vicinity of the McMurdo Sound. Here, we report results from a geographically extensive sampling across the Ross Sea conducted in December 2020. Material from plankton net tows (20µm mesh), made at 38 stations spanning over 30° of latitude, was examined. We found 11 tintinnid species of varying commonality or rarity, many showing considerable morphological variability that is here documented. We found four forms that had not been previously reported from the Ross Sea. Based on our findings and previous reports, we assembled a species accumulation curve showing the growth in the inventory of tintinnid species recorded from the Ross Sea as a function of sampling effort and time since 1983. Extrapolation of the species accumulation curve, derived from sampling over the last 37 years, indicates that continued sampling will likely provide new species records, suggesting that the Ross Sea is under-sampled at present. This complicates efforts to detect temporal changes in species compositions, at least with regard to tintinnid ciliates. Comparing species accumulation curves for the Ross Sea and the relatively well-studied Weddell Sea, it appears that the Ross Sea may be more species-rich.

keywords: Ross Sea Marine Protected Area, Antarctica, plankton, biodiversity

In the Antarctic coast, ice shelves are rapidly thinning and retreating due to global warming. Basal melt water influences marine life, particularly the phytoplankton, which are directly affected by changes in physicochemical environments. However, there is limited *in situ* data over large areas in the Amundsen Sea, which is currently a hotspot for rapidly thinning ice shelves in West Antarctica. During the austral summer cruise of 2020, phytoplankton species abundance was investigated along the Amundsen Sea coast using an automated continuous observation instrument, the Imaging FlowCytobot. The phytoplankton community was dominated by *Phaeocystis antarctica* in most coastal waters of the Amundsen Sea, as previously reported; however, unexpected blooms of diatom *Dactyliosolen tenuijunctus* were observed throughout the Pine Island Bay region at a high dominance rate (~90%) and abundance ($>10^7$ cells l^{-1}). *D. tenuijunctus* is a weakly silicified diatom and its massive bloom in the water column has been rarely reported from the Antarctic Ocean. The dramatic difference in phytoplankton compositions between these adjacent polynyas probably indicates an unstable response of phytoplankton to ice melting conditions. They could play a different role in the marine food web and carbon flux compared to other diatoms and *P. antarctica*. Therefore, further research is warranted to predict the biological and biogeochemical impacts of future melting conditions.

keywords: phytoplankton; *Dactyliosolen tenuijunctus*; *Phaeocystis Antarctica*; Amundsen Sea; Antarctica

3-62 *Environmental Sciences & Ecology; Meteorology & Atmospheric Sciences*
Unprecedented differences in phytoplankton community structures in the Amundsen Sea Polynyas, West Antarctica

Lee, Youngju., Park, Jisoo., Jung, Jinyoung. and **Kim, Tae Wan.**

Environmental Research Letters. 2022. 17(11).

doi: 10.1088/1748-9326/ac9a5f

3-63 *Environmental Sciences & Ecology; Marine & Freshwater Biology*
Variability in the Carbon and Nitrogen Uptake Rates of Phytoplankton Associated With Wind Speed and Direction in the Marian Cove, Antarctica

Kim, Bo Kyung., Jeon, Misa., Park, Sang-Jong., Kim, Hyun-Cheol., Min, Jun-Oh., Park, Jisoo. and **Ha, Sun-Yong.**

Frontiers in Marine Science. 2022. 9.

doi: 10.3389/fmars.2022.887909

Quantifying the temporal variability in phytoplankton productivity is essential for improving our understanding of carbon (C) and nitrogen (N) dynamics and energy flows in natural aquatic ecosystems.

Samples were collected at three-day intervals from December 2018 to January 2019 from fixed station in Marian Cove, Antarctica to determine the C and N (NO_3^- and NH_4^+) uptake by phytoplankton. Considerable fluctuations in the total C and N productivities were observed, which led to dynamic changes in the phytoplankton communities and a stronger coupling between the phytoplankton biomass. The increased rate of NO_3^- uptake coincided with an enhanced C uptake mainly by microphytoplankton ($>20\ \mu\text{m}$), followed by an increase in NH_4^+ uptake towards the end of sampling period. However, the $<2\ \mu\text{m}$ fraction (picophytoplankton) showed little variation in C and NO_3^- uptake, and the proportions of assimilated NH_4^+ contributed to more than half of the total assimilated inorganic N. The increased NH_4^+ did not increase the total phytoplankton biomass and C production. Interestingly, after January 9 (maximum chlorophyll a, C, and N uptake) there was a shift to a predominantly easterly wind ($>6\ \text{m s}^{-1}$), which rapidly decreased the total chl-a, C and N uptake rate to $\sim 4\%$ of the highest values ($0.6\ \text{mg m}^{-3}$, $1.0\ \text{mg C m}^{-3}\ \text{h}^{-1}$, $0.1\ \text{mg N m}^{-3}\ \text{h}^{-1}$, respectively) on January 12. The phytoplankton community was also replaced by neritic and ice-related species. These findings suggest that strong temporal shifts in phytoplankton C and N assimilation are strongly influenced by external forces (wind stress).

keywords: Antarctica; Marian Cove; carbon uptake rate; phytoplankton; stable isotope

in the Nordic Seas. The salinity variability was larger in the Greenland Sea (GS) than in the Norwegian Sea (NS) on both time scales of seasonal and interannual. The seasonal change of GS salinity was coincident with the seasonality of sea ice extent. The longer-time variations are decomposed by empirical orthogonal function (EOF) analysis. The GS salinity is mainly affected by current advection (29%) and sea ice extent (11%). The interannual response of salinity to the sea ice extent over the GS differs by season. NS salinity variability responds to the strength of the Subpolar Gyre associated with a large-scale atmospheric system that caused the freshening event in the mid-1990s. The propagation of the northward Atlantic Water core is observed over the period of about 3 years from the Faroe Shetland Channel to the Fram Strait at a speed of $2.6\text{--}6.5^\circ\ \text{year}^{-1}$. Other freshening factors such as sea ice export from the Arctic, freshwater flux at the Fram Strait, and net precipitation are also discussed. For the past three decades, the continuous trend appeared only in the sea ice extent, which might be a signal of climate changes over high latitude. However, there was no significant trend other than the periodic change in a few years to the decadal time scale in the salinity of GS and NS. As preconditioning for deep convection, near-surface salinity within Greenland Sea Gyre was influenced by salinity fluctuation in both GS and NS.

keywords: near-surface salinity; the Nordic Seas; surface freshening; reanalysis data; deep convection; climate change

3-64 *Environmental Sciences & Ecology; Marine & Freshwater Biology*

Variability of Near-Surface Salinity in the Nordic Seas Over the Past Three Decades (1991-2019)

Park, Ji-Eun., Kim, Hyun-Cheol. and Cho, Kyoung-Ho.

Frontiers in Marine Science. 2022. 9.

doi: 10.3389/fmars.2022.969159

The Nordic Seas have been widely implicated by deep water formation as a part of Atlantic Meridional Overturning Circulation. This study explores the spatiotemporal variations in the near-surface salinity over the Nordic Seas associated with surface freshening factors by using monthly TOPAZ4 reanalysis data from 1991 to 2019. We first show that reliability of TOPAZ4 data compared to the salinity products of other reanalysis data, satellite data, and *in-situ* measurements

3-65 *Oceanography*

Winter distribution of diatom assemblages along the coastline of R. O. Korea in 2010

Park, Joon Sang., Lee, Kyun-Woo., Jung, Seung Won., Lee, Taek-Kyun. and Joo, Hyoung Min.

Acta Oceanologica Sinica. 2022. 41(6): 68-77.

doi: 10.1007/s13131-021-1929-5

Diatoms are a globally successful and eukaryotic photosynthetic organism with an ornamented silica external wall. The relationship between their valve morphology and habitat means that diatoms can be used as bioindicators to characterize the aquatic environment. To estimate the differential distribution and diversity of diatom assemblages along the coastal line, we collected phytoplankton samples from 114 coastal sites of waters of R. O. Korea. We applied the

unweighted pair-group technique using the arithmetic averages clustering method to cluster the sampling sites, apart from those where the biota consisted of other groups, such as dinoflagellates, into four regions: the Yellow Sea, South Sea, southern East Sea, and northern East Sea. Indicator species analysis in each region led to the selection of tycho planktonic, chain-forming, attached species to substrates and psychrophilic indicator diatoms, respectively, each of which represented a planktonic lifestyle associated with one of the four regions. This study shows the diatom assemblages to serve as bioindicators of Korean coastal water in winter, and the subsequent seasonal survey will provide a starting point for the improved understanding of Korean diatom-based ecoregions, in both time and space.

keywords: diatom assemblage; indicator species; life-form; Korean coastal waters; species diversity

PART 4

Life Sciences

4-1 *Environmental Sciences & Ecology*

Abundance and diversity of antibiotic resistance genes and bacterial communities in the western Pacific and Southern Oceans

Jang, Jiyeon., Park, Jiyeon., Hwang, Chung Yeon., **Choi, Jinhee.,** Shin, Jingyeong., Kim, Young Mo., Cho, Kyung Hwa., **Kim, Jung-Hyun., Lee, Yung Mi.** and **Lee, Bang Yong.**

Science of the Total Environment. 2022. 822.

doi: 10.1016/j.scitotenv.2022.153360

This study investigated the abundance and diversity of antibiotic resistance genes (ARGs) and the composition of bacterial communities along a transect covering the western Pacific Ocean (36°N) to the Southern Ocean (74°S) using the Korean icebreaker R/V Araon (total cruise distance: 14,942 km). The relative abundances of ARGs and bacteria were assessed with quantitative PCR and next generation sequencing, respectively. The absolute abundance of ARGs was $3.0 \times 10^6 \pm 1.6 \times 10^6$ copies/mL in the western Pacific Ocean, with the highest value (7.8×10^6 copies/mL) recorded at a station in the Tasman Sea (37°S). The absolute abundance of ARGs in the Southern Ocean was 1.8-fold lower than that in the western Pacific Ocean, and slightly increased (0.7-fold) toward Terra Nova Bay in Antarctica, possibly resulting from natural terrestrial sources or human activity. beta-Lactam and tetracycline resistance genes were dominant in all samples (88-99%), indicating that they are likely the key ARGs in the ocean. Correlation and network analysis showed that *Bdellovibrionota*, *Bacteroidetes*, *Cyanobacteria*, *Margulisbacteria*, and *Proteobacteria* were positively correlated with ARGs, suggesting that these bacteria are the most likely ARG carriers. This study highlights the latitudinal profile of ARG distribution in the open ocean system and provides insights that will help in monitoring emerging pollutants on a global scale.

keywords: Antibiotic resistance; Marine bacteria; Latitudinal distribution; Open ocean system; Network analysis

Afrormosin exerts an anticancer effect via MAPK and AKT signaling pathways in B16F10 cells

Kim, Huiji., Han, Minjoo., Shin, Seong-Ah., An, Jangeun., Ahn, Mi-Jeong., **Lee, Jun Hyuck.** and 2 others.

Applied Biological Chemistry. 2022. 65(1).

doi: 10.1186/s13765-022-00743-5

Melanoma is a deadly skin cancer with high mortality, and its incidence is increasing every year. Although numerous anticancer drugs have been developed, these treatments have various side effects, such as skin rash, fatigue, diarrhea, cough, and muscle pain. Therefore, there is a need for research on novel anticancer drugs with low cytotoxicity and few side effects. In this study, we investigated whether afrormosin (7-hydroxy-4',6-dimethoxyisoflavone), a member of the isoflavonoid family, could have the potential as a novel anticancer drug. Afrormosin decreased the viability of B16F10 melanoma cells in a time- and dose-dependent manner. We also found that the afrormosin-induced decrease in cell viability was caused by the reduction of cell proliferation through G₀/G₁ arrest and the induction of apoptosis in B16F10 melanoma cells. Furthermore, afrormosin decreased the metastatic activity (cell invasion and migration) of B16F10 melanoma cells. At the molecular level, afrormosin reduced the levels of Bcl-2, an anti-apoptotic protein, and augmented the levels of Bax, a pro-apoptotic protein, and p53, a tumor suppressor. Additionally, procaspase-3 levels were reduced by afrormosin treatment. When we examined the signaling pathways affected by afrormosin, we found that the AKT/ERK pathways were inhibited and the p38/JNK pathway was activated by afrormosin. Collectively, these results suggest the potential anticancer effect of afrormosin, making it a prospective candidate for development as an anticancer drug.

keywords: Afrormosin; Phytochemical; Anticancer

Genes. 2022. 13(5).

doi: 10.3390/genes13050922

Meso- and macrozooplankton play crucial roles in the trophic web and the biological carbon pump in the ocean by transferring energy from lower to higher trophic levels and vertically exporting carbon from the surface to the deep ocean and seabed. In this study, zooplankton community structures in the Ross Sea, Antarctica, were analyzed using metabarcoding methods. Both regular barcode (RB) (using a PacBio Sequel system) and mini barcode (MB) (using the Illumina MiSeq platform) methods were utilized. As the result of a combination of the two bioinformatic pipelines used in the RB, 55 reliable haplotypes were obtained from the pooled zooplankton net samples, whereas 183 amplicon sequence variants (ASVs) were isolated from the MB metabarcoding analyses of 14 individual stations. Among these, 39 (70.9%) and 125 (90.6%) showed higher than 99% sequence identity to the database, indicating that there were sufficient reference sequences to employ metabarcoding analysis-except for several taxa, including small-sized copepods, cnidarians, and pneumodermatids. A high degree of shared taxa showed that both metabarcoding analyses were feasible for use in the analysis of zooplankton assemblages in the Ross Sea. However, RB would be more useful for the construction of a reference database due to its relatively high cost, whereas MB would be more economic for ecological surveys due to its relatively low cost (albeit, only if reference sequences were well documented using RB). Zooplankton assemblages were highly diverse in each sample site, presumably due to the narrow covered volumes of the vertical net-towed samples from polynyas in the Ross Sea. As metabarcoding data accumulate, we will gain better insights into zooplankton communities and their ecological implications in the Ross Sea.

keywords: Ross Sea; metabarcoding; zooplankton; next-generation sequencing; antarctica

Application of Dual Metabarcoding Platforms for the Meso- and Macrozooplankton Taxa in the Ross Sea

Lee, Ji-Hyun., **La, Hyoung Sul., Kim, Jeong-Hoon., Son, Wuju.** and 3 others.

Bioactive Secondary Metabolites Isolated from the Antarctic Lichen *Himantormia lugubris*

Koo, Man Hyung., Shin, Min-Ji., **Kim, Min Ju.,** Lee, Seulah., **So, Jae Eun., Kim, Ji Hee., Lee, Jun Hyuck.,** Suh, Sung-Suk.

and **Youn, Ui Joung.**

Chemistry & Biodiversity. 2022. 19(10).

doi: 10.1002/cbdv.202200374

Two new depsidones, himantormiones A and B (1 and 2) were isolated and identified from the Antarctic lichen, *Himantormia lugubris* (Parmeliaceae), with seven known compounds (3-9). The structures of two new compounds (1 and 2) were determined by means of spectroscopic analyses, including 1D and 2D NMR and HR-MS. The isolated compounds were tested for antimicrobial and cytotoxic activities, where himantormione B (2) exhibited inhibitory effect against *Staphylococcus aureus* with the IC_{50} value of 7.01 ± 0.85 μ M. Compound 2 also exhibited strong cytotoxic activity against HCT116 cells (colon cancer) with the EC_{50} value of 1.11 ± 0.85 μ M, where that of the positive control, 5-fluorouracil, was 9.4 ± 1.90 μ M.

keywords: *Himantormia lugubris*; depsidone; antimicrobial; cytotoxicity; lichen

4-5 *Biochemistry & Molecular Biology; Chemistry*

Bioactive Terphenyls Isolated from the Antarctic Lichen *Stereocaulon alpinum*

Phi, Kim-Hoa., Shin, Min-Ji., Lee, Seulah., So, Jae Eun., Kim, Ji Hee., Suh, Sung-Suk., Koo, Man Hyung., Shin, Seung Chul., Kim, Jin-Hyoung., Lee, Jun Hyuck. and Youn, Ui Joung.

Molecules. 2022. 27(7).

doi: 10.3390/molecules27072363

Three *p*-terphenyls (2-4)-2-hydroxy-3,5-dimethoxy-*p*-terphenyl (2), 2-hydroxy-3,6-dimethoxy-*p*-terphenyl (3), and 2,3,5,6-tetramethoxy-*p*-terphenyl (4)-were isolated for the first time as natural products along with seven known compounds (1, 5-10) from the Antarctic lichen *Stereocaulon alpinum*. Structures of the new compounds were elucidated by comprehensive analyses of 1D and 2D NMR and HREIMS experiments. Compound 3 exhibited cytotoxicity against HCT116 cells with the IC_{50} value of 3.76 ± 0.03 μ M and also inhibited NO production in LPS-induced RAW264.7 macrophages with the IC_{50} value of 22.82 ± 0.015 μ M.

keywords: *Stereocaulon alpinum*; Antarctic lichen; terphenyl; cytotoxicity; anti-inflammation

4-6 *Environmental Sciences & Ecology*

Characterization of antimicrobial resistance genes and virulence factor genes in an Arctic permafrost region revealed by metagenomics

Kim, Heesoo., Kim, Mincheol., Kim, Sanghee., Lee, Yung Mi. and Shin, Seung Chul.

Environmental Pollution. 2022. 294.

doi: 10.1016/j.envpol.2021.118634

Antimicrobial resistance genes (ARGs) and virulence factor genes (VFGs) constitute a serious threat to public health, and climate change has been predicted to affect the increase in bacterial pathogens harboring ARGs and VFGs. However, studies on bacterial pathogens and their ARGs and VFGs in permafrost region have received limited attention. In this study, a metagenomic approach was applied to a comprehensive survey to detect potential ARGs, VFGs, and pathogenic antibiotic resistant bacteria (PARB) carrying both ARGs and VFGs in the active layer and permafrost. Overall, 70 unique ARGs against 18 antimicrobial drug classes and 599 VFGs classified as 38 virulence factors were detected in the Arctic permafrost region. Eight genes with mobile genetic elements (MGEs) carrying ARGs were identified; most MGEs were classified as phages. In the metagenome-assembled genomes, the presence of 15 PARB was confirmed. The soil profile showed that the transcripts per million (TPM) values of ARGs and VFGs in the sub-soil horizon were significantly lower than those in the top soil horizon. Based on the TPM value of each gene, major ARGs, VFGs, and these genes in PARB from the Arctic permafrost region were identified and their distribution was confirmed. The major host bacteria for ARGs and VFGs and PARB were identified. A comparison of the percentage identity distribution of ARGs and VFGs to reference databases indicated that ARGs and VFGs in the Arctic soils differ from previously identified genes. Our results may help understand the characteristics and distribution of ARGs, VFGs, and these genes in PARB in the Arctic permafrost region. This findings suggest that the Arctic permafrost region may serve as potential reservoirs for ARGs, VFGs, and PARB. These genes could pose a new threat to human health if they are released by permafrost thawing owing to global warming and propagate to other regions.

keywords: Arctic permafrost region; Antimicrobial

4-7 Science & Technology - Other Topics

Comparative structural insight into the unidirectional catalysis of ornithine carbamoyltransferases from *Psychrobacter* sp. PAMC 21119

Do, Hackwon., Nguyen, Dieu Linh., Lee, Chang Woo., Lee, Min Ju., Oh, Hoejung., Hwang, Jisub., Han, Se Jong., Lee, Sung Gu. and Lee, Jun Hyuck.

Plos One. 2022. 17(9).

doi: 10.1371/journal.pone.0274019

Ornithine carbamoyltransferases (OTCs) are involved in the arginine deiminase (ADI) pathway and in arginine biosynthesis. Two OTCs in a pair are named catalytic OTC (cOTC) and anabolic OTC (aOTC). The cOTC is responsible for catalyzing the third step of the ADI pathway to catabolize citrulline into carbamoyl phosphate (CP), as well as ornithine, and displays CP cooperativity. In contrast, aOTC catalyzes the biosynthesis of citrulline from CP and ornithine *in vivo* and is thus involved in arginine biosynthesis. Structural and biochemical analyses were employed to investigate the CP cooperativity and unidirectional function of two sequentially similar OTCs (32.4% identity) named *Ps_cOTC* and *Ps_aOTC* from *Psychrobacter* sp. PAMC 21119. Comparison of the trimeric structure of these two OTCs indicated that the 80s loop of *Ps_cOTC* has a unique conformation that may influence cooperativity by connecting the CP binding site and the center of the trimer. The corresponding 80s loop region of *Ps_aOTC* was neither close to the CP binding site nor connected to the trimer center. In addition, results from the thermal shift assay indicate that each OTC prefers the substrate for the unidirectional process. The active site exhibited a blocked binding site for CP in the *Ps_cOTC* structure, whereas residues at the active site in *Ps_aOTC* established a binding site to facilitate CP binding. Our data provide novel insights into the unidirectional catalysis of OTCs and cooperativity, which are distinguishable features of two metabolically specialized proteins.

4-8 Biochemistry & Molecular Biology; Chemistry

Comparison of Fatty Acid Contents and MMP-1 Inhibitory Effects of the Two Antarctic Fish, *Notothenia rossii* and *Champscephalus gunnari*

Lee, Seulah., Koo, Man Hyung., Han, Dong-Won., Kim, Il-Chan., Lee, Jun Hyuck., Kim, Jeong-Hoon., Sultana, Razia., Kim, Sun Yeou., Youn, Ui Joung. and Kim, Jin-Hyoung.

Molecules. 2022. 27(14).

doi: 10.3390/molecules27144554

Total fatty-acid (FA) contents of different organs (stomach, liver, brain, and skin) of two Antarctic fish, marbled rockcod (*Notothenia rossii*) and mackerel icefish (*Champscephalus gunnari*), were examined using gas chromatography-mass spectrometry (GC-MS). *N. rossii* possessed higher contents of total omega-3, where eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), the most represented omega-3 FAs, were distributed throughout all parts of the fish. The highest level of EPA was observed in the skin and that of DHA was observed in the brain of *N. rossii*. *C. gunnari* showed organ peculiarity in that most of the omega-3 FAs were found in stomach and skin. Specifically, the highest levels of EPA and DHA were both observed in the stomach. Although *N. rossii* and *C. gunnari* both inhabit the Antarctic Southern Oceans, their characteristics in terms of the composition of fatty acids were shown to vary. The extracts were also evaluated for matrix metalloproteinase-1 (MMP-1)-inhibitory activities in UVB-induced human dermal fibroblasts, where extracts of the skin and liver of *N. rossii* showed the most significant inhibition upon MMP-1 production. These findings provide experimental evidence that the extracts of the Antarctic fish could be utilized as bioactive nutrients, particularly in the enhancement of skin health.

keywords: Antarctic fish; *Notothenia rossii*; *Champscephalus gunnari*; omega-3; polyunsaturated fatty acids; MMP-1 inhibition

4-9 Genetics & Heredity

The complete chloroplast genome sequence of a medicinal citrus landrace, *Citrus erythrosa* Hort. ex Tanaka in Jeju Island, Korea

Shin, Seung Chul., Song, Ji Hoon., Yoo, Yo-Han., Lee,

Joo-Sang, Kang, Seong-Il, Kim, Hee Jeong., **Lee, Hyungseok**, and Kim, Ho Bang.

Mitochondrial DNA Part B-Resources. 2022. 7(4): 580-582.

doi: 10.1080/23802359.2022.2057243

Citrus erythrosa (Dongjeongkyool in Korean) is a medicinal citrus landrace that grows in Korea. In this study, we characterized the complete chloroplast (Cp) genome (160,120 bp) of *C. erythrosa*. The Cp genome was consisted of 4 distinct regions: a large single copy (87,731 bp), a small single copy (18,393 bp), and a pair of inverted repeat regions (26,998 bp). The Cp genome encodes a total of 133 genes including 88 protein-coding genes, 37 tRNA genes and 8 rRNA genes. The phylogenetic analysis reveals that *C. erythrosa* is a sister group to the clade of species including *C. reticulata* within the genus *Citrus*.

keywords: *Citrus erythrosa*; landrace; medicinal fruit; chloroplast genome; phylogenetic analysis

the conversion of acetate to acetyl-CoA, gluconeogenesis, and energy storage that are all advantageous to oligotrophic bacteria. The presence of genes involved in osmotic balance, fatty acid desaturation, cold and heat shock responses, and the oxygen affinities of respiratory oxidases are likely associated with high tolerance to strong gradients of salinity, temperature and oxygen concentration.

keywords: Adaptation; Gradient; Salinity; Temperature; Tolerance

4-11

Complete Genome Sequence and Comparative Genome Analysis of *Variovorax* sp. Strains PAMC28711, PAMC26660, and PAMC28562 and Trehalose Metabolic Pathways in Antarctica Isolates

Prasansah Shrestha., Jayram Karmacharya., So-Ra Han., **Jun Hyuck Lee**, and 2 others.

International Journal of Microbiology. 2022. 1-13.

doi: 10.1155/2022/5067074

The complete genomes of *Variovorax* strains were analyzed and compared along with the genomes of *Variovorax* strains PAMC28711, PAMC28562, and PAMC26660, Antarctic isolates. The genomic information was collected from the NCBI database and the CAZyme database, and Prokka annotation was used to find the genes that encode for the trehalose metabolic pathway. Likewise, CAZyme annotation (dbCAN2 Meta server) was performed to predict the CAZyme family responsible for trehalose biosynthesis and degradation enzymes. Trehalose has been found to respond to osmotic stress and extreme temperatures. As a result, the study of the trehalose metabolic pathway was carried out in harsh environments such as the Antarctic, where bacteria *Variovorax* sp. strains PAMC28711, PAMC28562, and PAMC26660 can survive in extreme environments, such as cold temperatures. The trehalose metabolic pathway was analyzed via bioinformatics tools, such as the dbCAN2 Meta server, Prokka annotation, Multiple Sequence Alignment, ANI calculator, and PATRIC database, which helped to predict trehalose biosynthesis and degradation genes' involvement in the complete genome of *Variovorax* strains. Likewise, MEGA X was used for evolutionary and conserved genes. The complete genomes of *Variovorax* strains PAMC28711, PAMC26660, and

4-10 Genetics & Heredity; Marine & Freshwater Biology

Complete genome of *Nocardioides aquaticus* KCTC 9944^T isolated from meromictic and hypersaline Ekho Lake, Antarctica

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

Marine Genomics. 2022. 62.

doi: 10.1016/j.margen.2021.100889

Nocardioides aquaticus KCTC 9944^T is an aerobic, non-motile, Gram-positive, psychrotolerant, non-spore-forming bacterium isolated from the surface water of Ekho Lake in the Vestfold Hills, East Antarctica. This meromictic lake separated from Antarctic seawater thousands of years ago exhibits steep gradients of salinity and temperature in the upper layer of the water column. The cells of *N. aquaticus* thriving in Ekho Lake are able to grow in wide ranges of temperature (3 to 43.5°C) and salinity (0 to 15% NaCl). Here, we sequenced the complete genome of *N. aquaticus* KCTC 9944^T, aiming to better understand the adaptation of this bacterium to the strong environmental gradients at the molecular level. The genome consists of 4,580,814 bp (G + C content of 73.2%) with a single chromosome, 4432 protein-coding genes, 51 tRNAs and 2 rRNA operons. The genome possesses genes for the Entner-Doudoroff pathway, photoheterotrophy,

PAMC28562 are circular chromosomes of length (4,320,000, 7,390,000, and 4,690,000) bp, respectively, with GC content of (66.00, 66.00, and 63.70)%, respectively. The GC content of these three *Variovorax* strains is lower than that of the other *Variovorax* strains with complete genomes. Strains PAMC28711 and PAMC28562 exhibit three complete trehalose biosynthetic pathways (OtsA/OtsB, TS, and TreY/TreZ), but strain PAMC26660 only possesses one (OtsA/OtsB). Despite the fact that all three strains contain trehalose, only strain PAMC28711 has two trehaloses according to CAZyme families (GH37 and GH15). Moreover, among the three Antarctica isolates, only strain PAMC28711 exhibits auxiliary activities (AAs), a CAZyme family. To date, although the *Variovorax* strains are studied for different purposes, the trehalose metabolic pathways in *Variovorax* strains have not been reported. Further, this study provides additional information regarding trehalose biosynthesis genes and degradation genes (trehalase) as one of the factors facilitating bacterial survival under extreme environments, and this enzyme has shown potential application in biotechnology fields.

4-12

Complete Genome Sequence of *Brevibacterium frigoritolerans* Ant232, Isolated from Antarctic Snow

Choe, Young-hoe., Lee, Jong Ik. and Kim, Mincheol

AMER SOC MICROBIOLOGY. 2022. 11(5): 1-2.

doi: 10.1128/mra.00152-22

We report the complete and circularized genome sequences of *Brevibacterium frigoritolerans* Ant232, generated using a combination of Illumina and PacBio platforms. The high-quality complete genome consists of a circular 5,586,945-bp chromosome and a 305,498-bp plasmid, with G1C contents of 40.66% and 36.8%, respectively.

4-13 Life Sciences & Biomedicine - Other Topics

Complete genome sequence of plant-pathogenic *Pseudomonas* sp. N3-W isolated from subarctic tundra soil

Kim, Dockyu., Woo, Sungho., Lee, Jungeun., Kim, Sanghee. and Lee, Yung Mi.

Korean Journal of Microbiology. 2022. 58(4): 302-304.

doi: 10.7845/kjm.2022.2064

Pseudomonas sp. N3-W, a bacterial plant pathogen isolated from a subarctic Alaskan tundra soil for its ability to secrete strong extracellular protease(s), was found to be capable of producing brown spots on hot pepper leaves. The complete genome sequence consisted of one circular chromosome with 6,674,931 bp (G + C content of 59.7%). A computer-aided analysis discovered 5,726 protein coding sequences (CDSs), of which at least nine CDSs were putatively assigned to code for various proteolytic enzymes. The production of these proteases would explain N3-W's high degree of extracellular proteolytic activity, which could contribute to the evasion and deactivation of defense mechanisms of plant hosts.

keywords: bacterial pathogen; cold-adapted; crop yield; global warming; permafrost soil

4-14 Genetics & Heredity; Marine & Freshwater Biology

Complete genome sequence of *Rhodoferrax* sp. PAMC 29310 from a marine sediment of the East Siberian Sea

Lee, Yung Mi., Park, Yerin., Kim, Heesoo. and Shin, Seung Chul.

Marine Genomics. 2022. 62.

doi: 10.1016/j.margen.2021.100891

Rhodoferrax sp. PAMC 29310 was isolated from a surface marine sediment of the East Siberian Sea, Arctic. Whole-genome sequencing of the strain *Rhodoferrax* sp. PAMC 29310 was achieved using PacBio RS II and Illumina platform. The resulting complete genome comprised of 4,593,249 base pairs (G + C content of 58.0%) with a single chromosome, 4546 protein-coding genes, 57 tRNAs and 6 rRNA operons. A complete set of genes encoding the enzymes of glycolysis and citric acid cycle were identified. No genes encoding ribulose 1,5-bisphosphate carboxylase/oxygenase (RuBisCO) and nitrogenase reductase (*nif*) were present indicating that strain PAMC 29310 is not capable of fixing of carbon and nitrogen. PAMC 29310 genome contains genes for dissimilatory and assimilatory nitrate reduction. Gene encoding choline dehydrogenase enzyme which functions at the first step in the synthesis of betaine, one of the most effective osmoprotectants,

was detected. In particular, among the genomes of the genus *Rhodoferrax* strains, gene encoding nitrite reductase (*nirK*), which reduces nitrite to nitric oxide and *tetA* gene encoding tetracycline resistance protein involved in the resistance to tetracycline were identified only in the genome of *Rhodoferrax* sp. PAMC 29310. As the first genome from the strain which was isolated from marine sediment in the genus *Rhodoferrax*, investigation of physiological characteristics based on the complete genome sequences will help understand the adaptation of *Rhodoferrax* sp. PAMC 29310 in the marine sediment.

keywords: *Rhodoferrax*; Genome sequence; East Siberian Sea; Marine sediment

4-15 Biodiversity & Conservation

The complete mitochondrial genome of the Antarctic fairy shrimp *Branchinecta gaini* Daday, 1910 (Branchiopoda, Anostraca, Branchinectidae)

Jo, Euna., Kim, Jin-Hyoung., Ko, Young Wook., Kim, Sanghee. and Kang, Seunghyun.

Biodiversity Data Journal. 2022. 10.

doi: 10.3897/BDJ.10.e94051

The complete mitochondrial genome of Antarctic fairy shrimp *Branchinecta gaini* Daday, 1910 was sequenced, assembled and annotated using next-generation sequencing technology. The mitogenome of *B. gaini* is circular at 15,536 bp in length, consisting of 13 protein-coding genes, 23 tRNAs, two rRNAs and two major non-coding regions. In particular, there are two tRNA^{Gly} genes and one non-coding region between these two tRNA^{Gly} genes. A phylogenetic tree was constructed using concatenated amino acid sequences of 13 protein-coding genes. It reveals that *B. gaini* is clustered with the Anostraca group within the Branchiopoda clade. This study helps us understand the evolution of Anostraca.

keywords: *Branchinecta gaini*; mitochondrial genome; Antarctica; fairy shrimp; Anostraca

4-16 Biodiversity & Conservation

The complete mitochondrial genome of the Arctic fairy shrimp *Branchinecta paludosa* (Müller, 1788) (Anostraca, Branchinectidae) from Sirius Passet, North Greenland

Kihm, Ji-Hoon., Jo, Euna., Park, Tae-Yoon S. and Kim, Bo-Mi.

Biodiversity Data Journal. 2022. 10.

doi: 10.3897/BDJ.10.e90200

Here we report the complete mitochondrial genome of the Arctic fairy shrimp, *Branchinecta paludosa* (Müller, 1788) (Anostraca, Branchinectidae), which was collected in the High Arctic of North Greenland. A complete 16,059 bp mitochondrion of *B. paludosa* was sequenced and assembled with the Illumina next generation sequencing platform. The *B. paludosa* mitogenome contains 13 PCGs, 22 tRNAs and 2 rRNA genes that are commonly observed in most metazoans and shows the conserved gene arrangement pattern of Anostraca. Our results of the phylogenomic analysis are consistent with the previous phylogenetic relationship, based on nuclear 18S ribosomal DNA. The *B. paludosa* mitogenome will be useful for understanding the geographical distribution and phylogenetic relationship of anostracans.

keywords: *Branchinecta paludosa*; Greenland anostra; caBranchinectidae; mitogenome; phylogeny

4-17 Microbiology

Contrasting Community Composition and Co-Occurrence Relationships of the Active Pico-Sized Haptophytes in the Surface and Subsurface Chlorophyll Maximum Layers of the Arctic Ocean in Summer

Sun, Ping., Liao, Yuyu., Wang, Ying., Yang, Eun-Jin., Jiao, Nianzhi., Lee, Youngju., Jung, Jinyoung., Cho, Kyoung-Ho., Moon, Jong-Kuk. and Xu, Dapeng.

Microorganisms. 2022. 10(2).

doi: 10.3390/microorganisms10020248

Haptophytes (Hacrobia: Haptophyta), which can perform phototrophic, phagotrophic, or mixotrophic nutritional modes, are critical for element cycling in a variety of aquatic ecosystems. However, their diversity, particularly in the changing Arctic Ocean (AO), remains largely unknown. In the present study, the biodiversity, community composition, and co-occurrence networks

of pico-sized haptophytes in the surface water and subsurface chlorophyll maximum (SCM) layer of the AO were explored. Our results found higher alpha diversity estimates in the surface water compared with in the SCM based on high-throughput sequencing of haptophyte specific 18S rRNA. The community composition of the surface water was significantly different from that of the SCM, and water temperature was identified as the primary factor shaping the community compositions. Prymnesiales (mostly *Chrysochromulina*), uncultured Prymnesiophyceae, and *Phaeocystis* dominated the surface water communities, whereas *Phaeocystis* dominated the SCM communities, followed by *Chrysochromulina*, uncultured Prymnesiophyceae, and the remaining taxa. The communities of the surface water and SCM layer developed relatively independent modules in the metacommunity network. Nodes in the surface water were more closely connected to one another than those in the SCM. Network stability analysis revealed that surface water networks were more stable than SCM networks. These findings suggest that SCM communities are more susceptible to environmental fluctuations than those in surface water and that future global changes (e.g., global warming) may profoundly influence the development, persistence, and service of SCM in the AO.

keywords: Arctic ecology; community structure; marine biodiversity; protist; microbial eukaryotes; prymnesiophytes

tertiary structure and use a 5% significance level, the null hypothesis of independence between amino acid replacement and gap location is rejected for ~65% of datasets. Via simulations that include substitution and insertion-deletion, we show that the test performs well with true alignments. When we simulate according to the null hypothesis and then apply the test to optimal alignments that are inferred by each of four widely used software packages, the null hypothesis is rejected too frequently. Via further simulations and analyses, we show that the overly frequent rejections of the null hypothesis are not solely due to weaknesses of widely used software for finding optimal alignments. Instead, our evidence suggests that optimal alignments are unrepresentative of true alignments and that biased evolutionary inferences may result from relying upon individual optimal alignments.

keywords: gaps; insertion; deletion; substitution

4-18

Correlations between alignment gaps and nucleotide substitution or amino acid replacement

Seo, Tae-Kun. and 2 others.

Proceedings of the National Academy of Sciences of the United States of America. 2022. 119(34).

doi: 10.1073/pnas.2204435119

To assess the conventional treatment in evolutionary inference of alignment gaps as missing data, we propose a simple nonparametric test of the null hypothesis that the locations of alignment gaps are independent of the nucleotide substitution or amino acid replacement process. When we apply the test to 1,390 protein alignments that are informed by protein

4-19 *Biochemistry & Molecular Biology Chemistry*

Crystal Structure and Biochemical Analysis of a Cytochrome P450 CYP101D5 from *Sphingomonas echinoides*

Subedi, Pradeep., Do, Hackwon., Lee, Jun Hyuck. and Oh, Tae-Jin.

International Journal of Molecular Sciences. 2022. 23(21).

doi: 10.3390/ijms232113317

Cytochrome P450 enzymes (CYPs) are heme-containing enzymes that catalyze hydroxylation with a variety of biological molecules. Despite their diverse activity and substrates, the structures of CYPs are limited to a tertiary structure that is similar across all the enzymes. It has been presumed that CYPs overcome substrate selectivity with highly flexible loops and divergent sequences around the substrate entrance region. Here, we report the newly identified CYP101D5 from *Sphingomonas echinoides*. CYP101D5 catalyzes the hydroxylation of β -ionone and flavonoids, including naringenin and apigenin, and causes the dehydrogenation of α -ionone. A structural investigation and comparison with other CYP101 families indicated that spatial constraints at the substrate-recognition site originate from the B/C loop. Furthermore, charge distribution at the substrate binding site may be important for substrate selectivity and the preference for CYP101D5.

keywords: α / β -ionone; crystal structure; cytochrome P450; X-ray crystallography

4-20 *Environmental Sciences & Ecology*

Diazotrophic activity and denitrification in two long-term chronosequences of maritime Antarctica

Perez, Cecilia A., **Kim, Mincheol.** and 2 others.
Science of the Total Environment. 2022. 809.
 doi: 10.1016/j.scitotenv.2021.152234

The main goals of this study were to identify whether key processes involved in microbial soil nitrogen transformations, such as diazotrophic activity and denitrification, the chemical properties of limiting elements in the soil, and microbial community structure, differ in the different successional stages of two long term chronosequences in maritime Antarctica. Moreover, we expect the rates of diazotrophic activity and denitrification to be stimulated by increases in air temperature and moisture. To answer these questions, we selected three stages in the succession (early, mid and late) in each of two well established chronosequences: three raised beaches in Ardley Island; and the Barton Peninsula, which includes two cosmogenically dated sites and the forefield of the Fourcade glacier. In the Ardley chronosequence, higher diazotrophic activity was found in the older successional stages, concomitant with an increase in the abundance of *Cyanobacteria*. In the Barton chronosequence, *Cyanobacteria* were only present and abundant (*Microcoleus*) in the early successional stage, coinciding with the highest diazotrophic activity. Denitrification in the Barton chronosequence tended to be highest at the mid successional sites, associated with the highest abundance of *Rhodanobacter*. In the Ardley chronosequence, the lowest abundance of *Rhodanobacter* was linked to lower denitrification rates in the mid successional stage. In the Ardley chronosequence, significant positive effects of passive warming and water addition on diazotrophic activity were detected in the first and the second years of the study respectively. In the Barton chronosequence on the other hand, there was no response to either passive warming or water addition, probably a manifestation of the higher nutrient limitation in this site. Denitrification showed no response to either warming or water addition. Thus, the response of

microbial nitrogen transformations to global change is highly dependent on the environmental setting, such as soil origin, age and climate regime.

keywords: King George Island; Soil microbial communities; Diazotrophs; Denitrifiers

4-21 *Environmental Sciences & Ecology*

Diel variations in chemical and isotopic compositions of a stream on King George Island, Antarctica: Implications for hydrologic pathways of meltwater

Jung, Hyejung., Jeon, Sung-Wook., **Lee, Hyoungseok.** and Lee, Jeonghoon.
Science of the Total Environment. 2022. 825.
 doi: 10.1016/j.scitotenv.2022.153784

Antarctica is highly susceptible to climate and environmental change. In particular, climate change can lead to the warming of permafrost and the development of active layers in permafrost areas, resulting in variations in hydrological characteristics. This study investigated the hydrological process associated with a stream in a snow-dominated headwater catchment on King George Island, maritime Antarctica, during austral summer using the chemical and isotopic compositions. During the cold period, as the snowmelt rate decreased, the amount of new water also decreased. Hence, the electrical conductivity (EC) increased because the contribution of supra-permafrost groundwater ("old" water), which occurs in the active layer, increased more during the cold period than during the warm period. Moreover, diel variations in the stable isotopic compositions ($\delta^{18}\text{O}$ and δD) of snowmelt ("new" water) were clearly observed in the stream water, indicating that runoff was the dominant flow path of snowmelt during the cold period. In contrast, during the warm period, the amount of snowmelt increased and the EC value decreased as a result of the dilution effect. In addition, compared with the cold period, diel variations in the isotopic compositions of the stream water were attenuated during the warm period. This attenuation effect was not due to the increased contribution of old water; instead, it was due to the contribution of new water with a low-amplitude signal in the diel variations of the isotopic compositions. Thus, the observed diel variations in the isotopic compositions of the stream water during cold and warm periods suggest that this

catchment is dominated by new water. These findings are helpful for improving our understanding of climate-related changes in the hydrological pathways and water-related ecosystems of polar catchments.

keywords: Permafrost hydrology; Hydrological environment; Stable water isotopes; Diel variation; Active layer; Antarctica

4-22 *Biodiversity & Conservation; Environmental Sciences & Ecology*

Dietary niche partitioning in brown skuas (*Stercorarius lonnbergi*) during the chick-rearing period at Nareški Point on King George Island, Antarctica

Kim, Youmin., Jung, Jin-Woo., Kim, Jong- U., Oh, Yeon-Soo., Chung, Hosung. and Kim, Jeong-Hoon.

Polar Biology. 2022. 45(1): 153-158.

doi: 10.1007/s00300-021-02971-9

Brown Skuas (*Stercorarius lonnbergi*) are known to feed on other birds or eggs during the breeding season. In some cases, however, a few pairs monopolize a penguin colony, and the other skuas mainly forage in the sea. We installed automatic camera traps to monitor two groups of breeding Brown Skua pairs on King George Island: the nests of Group A were located near a Gentoo Penguin (*Pygoscelis papua*) colony, while those of Group B were relatively far away. From the resulting photographs, we were able to distinguish the food items that parents brought to the nest and could confirm the egg hatching date. Overall, 97.1% of the food items that group A brought to the nest were from the penguin colonies, while 94.1% of the prey items of group B were fish. Group A had a hatching date at least 8 days earlier than Group B. Our results show that a few Brown Skua pairs that bred near the penguin colony fed primarily on penguin nest contents such as eggs or chicks within their feeding territory and had earlier hatching dates. The Brown Skuas that nested close to penguin nests may have had advantages in foraging and breeding performance.

keywords: *Stercorarius lonnbergi*; Diet composition; Territoriality; Hatching date; Antarctica

4-23 *Biochemistry & Molecular Biology; Chemistry; Polymer Science*

Dual functional roles of a novel bifunctional β -lactamase/esterase from *Lactococcus garvieae*

Yoo, Wanki., Wang, Ying., Jeon, Sangeun., **Kim, Han-Woo.** and 3 others.

International Journal of Biological Macromolecules. 2022. 206: 203-212.

doi: 10.1016/j.ijbiomac.2022.02.081

A novel bifunctional β -Lactamase/esterase (LgLacl), which is capable of hydrolyzing β -lactam-containing antibiotics including ampicillin, oxacillin, and cefotaxime as well as synthesizing biodiesels, was cloned from *Lactococcus garvieae*. Unlike most bacterial esterases/lipases that have G-x-S-x-G motif, LgLacl, which contains S-x-x-K catalytic motif, has sequence similarities to bacterial family VIII esterase as well as β -Lactamase. The catalytic properties of LgLacl were explored using a wide range of biochemical methods including spectroscopy, assays, structural modeling, mutagenesis, and chromatography. We confirmed the bifunctional property of LgLacl hydrolyzing both esters and β -lactam antibiotics. This study provides novel perspectives into a bifunctional enzyme from *L. garvieae*, which can degrade β -lactam antibiotics with high esterase activity.

keywords: LgLacl; Bifunctional enzyme; β -Lactamase/esterase; Antibiotics; Biodiesels

4-24 *Science & Technology - Other Topics*

The Earth BioGenome Project 2020: Starting the clock

Lewin, Harris A., Richards, Stephen, Aiden, Erez Lieberman, Allende, Miguel L., Archibald, John M., Balint, Miklos, Barker, Katharine B., Baumgartner, Bridget, Belov, Katherine, Bertorelle, Giorgio, Blaxter, Mark L., Cai, Jing, Caperello, Nicolette D., Carlson, Keith, Castilla-Rubio, Juan Carlos, Chaw, Shu-Miaw, Chen, Lei, Childers, Anna K., Coddington, Jonathan A., Conde, Dalia A., Corominas, Montserrat, Crandall, Keith A., Crawford, Andrew J., DiPalma, Federica, Durbin, Richard, Ebenezer, ThankGod E., Edwards, Scott V., Fedrigo, Olivier, Flicek, Paul, Formenti, Giulio, Gibbs, Richard A., Gilbert, M. Thomas P., Goldstein, Melissa M., Graves, Jennifer Marshall, Greely, Henry T., Grigoriev, Igor V., Hackett, Kevin J., Hall, Neil, Haussler, David, Helgen, Kristofer M., Hogg, Carolyn J., Isobe, Sachiko, Jakobsen, Kjetill Sigurd, Janke, Axel, Jarvis,

Erich D., Johnson, Warren E., Jones, Steven J. M., Karlsson, Elinor K., Kersey, Paul J., **Kim, Jin-Hyoung**, and 35 others.

Proceedings of the National Academy of Sciences of the United States of America. 2022. 119(4).

doi: 10.1073/pnas.2115635118

November 2020 marked 2 y since the launch of the Earth BioGenome Project (EBP), which aims to sequence all known eukaryotic species in a 10-y timeframe. Since then, significant progress has been made across all aspects of the EBP roadmap, as outlined in the 2018 article describing the project's goals, strategies, and challenges (1). The launch phase has ended and the clock has started on reaching the EBP's major milestones. This Special Feature explores the many facets of the EBP, including a review of progress, a description of major scientific goals, exemplar projects, ethical legal and social issues, and applications of biodiversity genomics. In this Introduction, we summarize the current status of the EBP, held virtually October 5 to 9, 2020, including recent updates through February 2021. References to the nine Perspective articles included in this Special Feature are cited to guide the reader toward deeper understanding of the goals and challenges facing the EBP.

4-25 *Environmental Sciences & Ecology; Evolutionary Biology*

Fecal microbiota and diets of muskox female adults and calves

Cheon, Ji-Yeon., Cho, Hyunjun., Kim, Mincheol., Park, Hyun Je., **Park, Tae-Yoon S.** and **Lee, Won Young.**

Ecology and Evolution. 2022. 12(5).

doi: 10.1002/ece3.8879

In mammals, the gut microbiome is vertically transmitted during maternal lactation at birth. In this study, we investigated the gut microbiome and diets of muskox, a large herbivore inhabiting in the high Arctic. We compared the microbiota composition using bacterial 16S rRNA gene sequencing and diets using stable isotope analysis of muskox feces of six female adults and four calves on Ella Island, East Greenland. Firmicutes were the most abundant bacterial phylum in both the adults and calves, comprising 94.36% and 94.03%, respectively. Significant differences were observed in the relative abundance of the two Firmicutes families. The adults were primarily

dominated by Ruminococcaceae (73.90%), and the calves were dominated by both Ruminococcaceae (56.25%) and Lachnospiraceae (24.00%). Stable isotope analysis of the feces in the study area revealed that both adults and calves had similar ranges of C-13 and N-15, likely derived from the dominant diet plants. Despite their similar diets, the different gut microbiome compositions in muskox adults and calves indicate that the gut microbiome of the calves may not be fully colonized to the extent of that of the adults.

keywords: diet analysis; gut microbiome; high Arctic; large herbivore; *Ovibos moschatu*

4-26 *Pharmacology & Pharmacy*

First Chemical Investigation of Korean Wild Mushroom, *Amanita hemibapha* subsp. *javanica* and the Identification of Anti-*Helicobacter pylori* Compounds

Lee, Seulah. and 7 others.

Pharmaceuticals. 2022. 15(2).

doi: 10.3390/ph15020152

Amanita hemibapha subsp. *javanica* (Amanitaceae) is an edible Korean wild mushroom. *A. hemibapha* subsp. *javanica* is often confused with *A. subjunquillea*, known as the East Asian death cap, which is potentially fatal when ingested. This study aimed to conduct the first chemical investigation of *A. hemibapha* subsp. *javanica*, which resulted in the isolation of seven fatty acid derivatives (1-7) and three steroids (8-10) from the MeOH extract of its fruiting bodies, and their structures were determined by comparing their NMR spectroscopic data with those previously reported, along with the data from LC/MS. Compound 1 was reported previously without the identification of its absolute configuration; its structure, including the absolute configuration was confirmed for the first time, in this study, by using ¹H NMR and its fragmentation patterns in MS/MS data, and LC/MS analysis. A recently developed method using competing enantioselective acylation (CEA) coupled with LC/MS analysis was applied for determining the absolute configuration of compound 1, which revealed the 11S-configuration. In the anti-*Helicobacter pylori* activity test, compound 3 showed antibacterial activity against *H. pylori* strain 51 with 38.0% inhibition, comparable to that of quercetin (34.4% inhibition) as a positive control. Specifically, compound 4 displayed the most potent antibacterial

activity against *H. pylori* strain 51 with 80.5% inhibition at the final concentration of 100 μm with a MIC₅₀ value of 72 μm . These findings suggested that the active compound 4 is a natural antibiotic that may be used in the development of novel antibiotics against *H. pylori*. In addition, the first chemical investigation of *A. hemibapha* subsp. *javanica* revealed that this mushroom can serve as a promising natural source for the bioactive natural products.

keywords: *Amanita hemibapha* subsp. *Javanica*; Amanitaceae; fatty acid derivatives; steroids; LC/MS analysis; CEA; anti-*H. pylori* activity

4-27 *Environmental Sciences & Ecology; Geology; Oceanography*

Five decades of terrestrial and freshwater research at Ny-Ålesund, Svalbard

Å.Ø. Pedersen, P. Convey, K.K. Newsham, J.B. Mosbacher, E. Fuglei, V. Ravolainen, B.B. Hansen, T.C. Jensen, A. Augusti, E.M. Biersma, E.J. Cooper, S.J. Coulson, G.W. Gabrielsen, J.C. Gallet, U. Karsten, S.M. Kristiansen, M.M. Svenning, A.T. Tveit, M. Uchida, I. Baneschi, E. Calizza, N. Cannone, E.M. de Goede, M. Doveri, J. Elster, M.S. Giamberini, K. Hayashi, S.I. Lang, **Lee, Yoo Kyung**, and 18 others.

Polar Research. 2022. 41(6310).

doi: 10.33265/polar.v41.6310

For more than five decades, research has been conducted at Ny-Ålesund, in Svalbard, Norway, to understand the structure and functioning of High Arctic ecosystems and the profound impacts on them of environmental change. Terrestrial, freshwater, glacial and marine ecosystems are accessible year-round from Ny-Ålesund, providing unique opportunities for interdisciplinary observational and experimental studies along physical, chemical, hydrological and climatic gradients. Here, we synthesize terrestrial and freshwater research at Ny-Ålesund and review current knowledge of biodiversity patterns, species population dynamics and interactions, ecosystem processes, biogeochemical cycles and anthropogenic impacts. There is now strong evidence of past and ongoing biotic changes caused by climate change, including negative effects on populations of many taxa and impacts of rain-on-snow events across multiple trophic levels. While species-level characteristics and responses are well understood for macro-organisms, major knowledge gaps exist for microbes, invertebrates and

ecosystem-level processes. In order to fill current knowledge gaps, we recommend (1) maintaining monitoring efforts, while establishing a long-term ecosystem-based monitoring programme; (2) gaining a mechanistic understanding of environmental change impacts on processes and linkages in food webs; (3) identifying trophic interactions and cascades across ecosystems; and (4) integrating long-term data on microbial, invertebrate and freshwater communities, along with measurements of carbon and nutrient fluxes among soils, atmosphere, freshwaters and the marine environment. The synthesis here shows that the Ny-Ålesund study system has the characteristics needed to fill these gaps in knowledge, thereby enhancing our understanding of High-Arctic ecosystems and their responses to environmental variability and change.

keywords: Biogeochemical cycles; climate change; ecosystem structure and functioning; environmental change; High Arctic; human impacts; soil

4-28 *Engineering; Environmental Sciences & Ecology*

Frozen Hydrogen Peroxide and Nitrite Solution: The Acceleration of Benzoic Acid Oxidation via the Decreased pH in Ice

Ahn, Yong-Yoon, Kim, Jungwon, and **Kim, Kitae**.

Environmental Science & Technology. 2022. 56(4): 2323-2333.

doi: 10.1021/acs.est.1c05705

We investigated benzoic acid oxidation via the reaction of hydrogen peroxide (H_2O_2) and nitrite (NO_2^-). The oxidation of benzoic acid by reactive nitrous acid (HONO) was negligible, and the reactivity of the $\text{H}_2\text{O}_2/\text{NO}_2^-$ system decreased with a decrease in temperature under aqueous conditions. However, freezing markedly accelerated the chemical reaction. Based on Raman microscope measurements, concentrated species were confirmed in certain regions of the ice. We proposed that the change in nitrite speciation (accordingly, a decrease in the pH below pK_a), derived from the freezing concentration effect, was the reason for the accelerated reactions. The oxidation characteristics of the system were monitored under varying conditions, such as initial pH, dosage ratio, benzoic acid concentration, and reaction with various benzene derivatives. The ultrahigh-performance liquid chromatography/electrospray ionization/mass

spectrometry (UHPLC/ESI/MS) measurement showed that peroxyxynitrous acid (HOONO)-mediated oxidation generated hydroxylated and nitrated byproducts. Additionally, decarboxylated products were detected, indicating direct electron transfer from the organic compounds to HOONO. As freezing is a global phenomenon, and H₂O₂ and NO₂⁻ are ubiquitous in the environment, the transformation of aromatic compounds with H₂O₂/NO₂⁻ in cold environments must be considered in environmental chemistry.

keywords: ice; peroxyxynitrous acid; benzoic acid; nitrous acid; freeze concentration

4-29 *Biochemistry & Molecular Biology; Biotechnology & Applied Microbiology*

Functional production, characterization, and immobilization of a cold-adapted cutinase from Antarctic *Rhodococcus* sp.

Won, Seok-Jae., **Yim, Joung Han.** and Kim, Hyung-Kwoun.
Protein Expression and Purification. 2022. 195.
doi: 10.1016/j.pep.2022.106077

A lipolytic enzyme (Rcut) was discovered from the *Rhodococcus* strain (RosL12) isolated from the Antarctic Ross Sea. The corresponding gene composed of 651 bases encoding 216 amino acids. It was found to be a cutinase gene through BLAST search. Rcut has a signal sequence consisting of 29 amino acids. An active Rcut was produced after the intact gene containing the signal sequence was transformed into *Escherichia coli* Rosetta-gamiTM 2 (DE3) pLysS. Rcut was purified through a nickel-nitrilotriacetic acid purification system and a carboxymethyl Sepharose column chromatography. Its specific activity was 2190 U/mg. Rcut showed the highest activity at 40°C and had a low activation energy of 3.16 kcal/mol. This means that it is a typical cold-adapted enzyme. Rcut showed high activity towards medium chain fatty acids (C₄-C₁₀). Rcut degraded polycaprolactone and polyethylene terephthalate, suggesting that it could be used for decomposition of synthetic plastics causing environmental pollution. Rcut was immobilized on methacrylate-divinyl benzene bead. This immobilized Rcut (immRcut) showed higher thermal stability than the free enzyme. ImmRcut performed transesterification of various esters and ethanol in a non-polar solvent, suggesting that it could be used for the synthesis of industrially useful ester compounds.

keywords: Cutinase; *Rhodococcus*; Cold-adapted; Functional production; Immobilization

4-30 *Science & Technology - Other Topics*

Gene family expansions in Antarctic winged midge as a strategy for adaptation to cold environments

Kim, Heesoo., Kim, Han-Woo., Lee, Jun Hyuck., Park, Joonho., **Lee, Hyoungseok., Kim, Sanghee.** and **Shin, Seung Chul.**

Scientific Reports. 2022. 12(1).

doi: 10.1038/s41598-022-23268-9

Parochlus steinenii is the only flying insect native to Antarctica. To elucidate the molecular mechanisms underlying its adaptation to cold environments, we conducted comparative genomic analyses of *P. steinenii* and closely related lineages. In an analysis of gene family evolution, 68 rapidly evolving gene families, involved in the innate immune system, unfolded protein response, DNA packaging, protein folding, and unsaturated fatty acid biosynthesis were detected. Some gene families were *P. steinenii*-specific and showed phylogenetic instability. Acyl-CoA delta desaturase and heat shock cognate protein 70 (Hsc70) were representative gene families, showing signatures of positive selection with multiple gene duplication events. Acyl-CoA delta desaturases may play pivotal roles in membrane fluidity, and expanded Hsc70 genes may function as chaperones or thermal sensors in cold environments. These findings suggest that multiple gene family expansions contributed to the adaptation of *P. steinenii* to cold environments.

4-31 *Agriculture; Veterinary Sciences; Zoology*

Genomic Survey and Microsatellite Marker Investigation of Patagonian Moray Cod (*Muraenolepis orangiensis*)

Choi, Eunkyung., Lee, Seung Jae., **Jo, Euna.,** Kim, Jinmu., Parker, Steven J., **Kim, Jeong-Hoon.** and Park, Hyun.

Animals. 2022. 12(13).

doi: 10.3390/ani12131608

Simple Summary Patagonian moray cod is known to inhabit the cold waters near Antarctica, and it belongs

to the *Muraenolepis* genus. This genus has seven species, and five of them are recently reported. The *Muraenolepis* genus has similar morphological characters, and this is a limitation of taxonomical classification. In this study, a genome survey and microsatellite marker analysis were conducted to characterize the genome profile for classification. As a result, genomic data such as genome size and microsatellite motifs were obtained. The *Muraenolepididae* family of fishes, known as eel cods, inhabits continental slopes and shelves in the Southern Hemisphere. This family belongs to the Gadiformes order, which constitutes one of the most important commercial fish resources worldwide, but the classification of the fish species in this order is ambiguous because it is only based on the morphological and habitat characteristics of the fishes. Here, the genome of Patagonian moray cod was sequenced using the Illumina HiSeq platform, and screened for microsatellite motifs. The genome was predicted to be 748.97 Mb, with a heterozygosity rate of 0.768%, via K-mer analysis ($K = 25$). The genome assembly showed that the total size of scaffolds was 711.92 Mb and the N50 scaffold length was 1522 bp. Additionally, 4,447,517 microsatellite motifs were identified from the genome survey assembly, and the most abundant motif type was found to be AC/GT. In summary, these data may facilitate the identification of molecular markers in Patagonian moray cod, which would be a good basis for further whole-genome sequencing with long read sequencing technology and chromosome conformation capture technology, as well as population genetics.

keywords: *Muraenolepis orangiensis*; Patagonian moray cod; microsatellite; SSR; Illumina

4-32 Microbiology

Glaciers as microbial habitats: current knowledge and implication

Kim, Soyeon., Lee, Hanbyul., Hur, Soon-Do., Sul, Woo Jun. and **Kim, Ok-Sun.**

Journal of Microbiology. 2022. 60(8): 767-779.

doi: 10.1007/s12275-022-2275-9

Glaciers, formed from the gradual accumulation of snow, can be continuous records representing past environments and recognized as a time capsule of our planetary evolution. Due to extremely harsh

conditions, glacial ice has long been considered an uninhabitable ecosystem for microorganisms to sustain their life. However, recent developments in microbiological analysis techniques revealed the presence of unexpectedly diverse microbial strains. Glacial microorganisms could also provide valuable information, including not only biological diversity and structure but also molecular systematics, metabolic profiles, and evolutionary changes from the past climate and ecosystem. However, there are several obstacles in investigating the glacier environment, such as low regional accessibility, technical difficulties of ice coring, potential contamination during the sampling process, and low microbial biomass. This review aims to summarize recent knowledge on decontamination methods, biomass, diversity based on culture-dependent and -independent methods, application of biological proxies, greenhouse gas production and adaptive strategies in glaciers from various regions and to imply further directions for a comprehensive understanding of habitability in an icy world including outer of our planet.

keywords: psychrophiles; microbial diversity; decontamination; biological proxy; adaptation; astrobiology

4-33 Microbiology

Hymenobacter siberiensis sp. nov., isolated from a marine sediment of the East Siberian Sea and *Hymenobacter psoromatis* sp. nov., isolated from an Antarctic lichen

Park, Yerin., Noh, Hyun-Ju., Hwang, Chung Yeon., **Shin, Seung Chul., Hong, Soon Gyu., Jin, Young Keun., Lee, Hyoungseok.** and **Lee, Yung Mi.**

International Journal of Systematic and Evolutionary Microbiology. 2022. 72(3).

doi: 10.1099/ijsem.0.005290

Gram-stain-negative, strictly aerobic, red-pink-coloured, rod-shaped and non-motile bacterial strains PAMC 29290, PAMC 29294^T and PAMC 29296 were isolated from marine surface sediment sampled in the East Siberian Sea and strains PAMC 26553 and PAMC 26554^T were obtained from an Antarctic lichen. Strains PAMC 29290, PAMC 29294^T and PAMC 29296 were closely related to *Hymenobacter artigasi* (98.8% 16S rRNA gene similarity), *Hymenobacter antarcticus* (97.3%) and

Hymenobacter glaciei (96.9%), and PAMC 26553 and PAMC 26554^T showed high similarity to *Hymenobacter ginsengisoli* (97.0%), *Hymenobacter rivuli* (96.1%) and *Hymenobacter setariae* (95.9%). Genomic relatedness analyses showed that strains PAMC 29290, PAMC 29294^T and PAMC 29296 could be distinguished from *H. artigasi* by average nucleotide identity (ANI; 93.1-93.2%) and digital DNA-DNA hybridization (dDDH; 50.3-51.0%) values. Strains PAMC 26553 and PAMC 26554^T could be clearly distinguished from *H. ginsengisoli* with ANI values <79.8% and dDDH values <23.3%. The major fatty acids of strains PAMC 29290, PAMC 29294^T and PAMC 29296 were C_{15:0} iso (21.0-26.0%), summed feature 3 (C_{16:1}, ω 7c and/or C_{16:1}, ω 6c; 17.4-18.2%), C_{15:0} anteiso (12.7-19.1%) and summed feature 4 (C_{17:1} iso I and/or anteiso B; 8.6-16.1%) and those of strains PAMC 26553 and PAMC 26554^T were summed feature 3 (C_{16:1} ω 7c and/or C_{16:1} ω 6c; 20.7-22.2%), C_{15:0} anteiso (17.5-19.7%) and summed feature 4 (C_{17:1} iso I and/or anteiso B; 15.5-18.1%). The major respiratory quinone was MK-7. The genomic DNA G+C contents were 60.6-60.8 mol%. The polar lipids of PAMC 29294^T were found to consist of phosphatidylethanolamine, four unidentified aminolipids, an unidentified aminophospholipid and five unidentified lipids; those of PAMC 26554^T were phosphatidylethanolamine, three unidentified aminolipids, four unidentified aminophospholipid and two unidentified lipids. The distinct phylogenetic position and some physiological characteristics distinguished the novel strains from closely related type strains in the genus *Hymenobacter*. Thus, two novel species are proposed, with the names *Hymenobacter siberiensis* sp. nov. (type strain, PAMC 29294^T=KCTC 82466^T=JCM 34574^T) and *Hymenobacter psoromatis* sp. nov. (type strain, PAMC 26554^T=KCTC 82466^T=JCM 34574^T), respectively.

keywords: *Hymenobacter siberiensis*; *Hymenobacter psoromatis*; polyphasic taxonomy

In this study, we have identified the entire complement of typical homeobox (*Hox*) genes (*Lab*, *Pb*, *Dfd*, *Scr*, *Antp*, *Ubx*, *Abd-A*, and *Abd-B*) in harpacticoid and calanoid copepods and compared them with the cyclopoid copepod *Paracyclopina nana*. The harpacticoid copepods *Tigriopus japonicus* and *Tigriopus kingsejongensis* have seven *Hox* genes (*Lab*, *Dfd*, *Scr*, *Antp*, *Ubx*, *Abd-A*, and *Abd-B*) and the *Pb* and *Ftz* genes are also present in the cyclopoid copepod *P. nana*. In the *Hox* gene cluster of the calanoid copepod *Eurytemora affinis*, all the *Hox* genes were present linearly in the genome but the *Antp* gene was duplicated. Of the three representative copepods, the *P. nana* *Hox* gene cluster was the most compact due to its small genome size. The *Hox* gene expression profile patterns in the three representative copepods were stage-specific. The *Lab*, *Dfd*, *Scr*, *Pb*, *Ftz*, and *Hox3* genes showed a high expression in early developmental stages but *Antp*, *Ubx*, *Abd-A*, and *Abd-B* genes were mostly expressed in later developmental stages, implying that these *Hox* genes may be closely associated with the development of segment identity during early development.

keywords: copepods; developmental stage; expression; *Hox* gene cluster

4-35 Biochemistry & Molecular Biology; Chemistry

Identification of Potential Anti-Neuroinflammatory Inhibitors from Antarctic Fungal Strain *Aspergillus* sp. SF-7402 via Regulating the NF-kappa B Signaling Pathway in Microglia

Cao, Thao Quyen., Liu, Zhiming., Dong, Linsha., Lee, Hwan., Ko, Wonmin., Vinh, Le Ba., Tuan, Nguyen Quoc., Kim, Youn-Chul., Sohn, Jae Hak., **Yim, Joung Han.** and 2 others.

Molecules. 2022. 27(9).

doi: 10.3390/molecules27092851

4-34 Evolutionary Biology; Developmental Biology; Zoology

Identification and characterization of homeobox gene clusters in harpacticoid and calanoid copepods

Kim, Duck-Hyun., Jeong, Haksoo., Kim, Min-Sub., **Kim, Sanghee.** and 4 others.

Journal of Experimental Zoology Part B-Molecular and Developmental Evolution. 2022. 338(4): 215-224.

doi: 10.1002/jez.b.23112

Microglia play a significant role in immune defense and tissue repair in the central nervous system (CNS). Microglial activation and the resulting neuroinflammation play a key role in the pathogenesis of neurodegenerative disorders. Recently, inflammation reduction strategies in neurodegenerative diseases have attracted increasing attention. Herein, we discovered and evaluated the anti-neuroinflammatory potential of compounds from the Antarctic fungi strain

Aspergillus sp. SF-7402 in lipopolysaccharide (LPS)-stimulated BV2 cells. Four metabolites were isolated from the fungi through chemical investigations, namely, 5-methoxysterigmatocystin (1), sterigmatocystin (2), aversin (3), and 6,8-*O*-dimethylversicolorin A (4). Their chemical structures were elucidated by extensive spectroscopic analysis and HR-ESI-MS, as well as by comparison with those reported in literature. Anti-neuroinflammatory effects of the isolated metabolites were evaluated by measuring the production of nitric oxide (NO), tumor necrosis factor (TNF)- α , and interleukin (IL)-6 in LPS-activated microglia at non-cytotoxic concentrations. Sterigmatocystins (1 and 2) displayed significant effects on NO production and mild effects on TNF- α and IL-6 expression inhibition. The molecular mechanisms underlying this activity were investigated using Western blot analysis. Sterigmatocystin treatment inhibited NO production via downregulation of inducible nitric oxide synthase (iNOS) expression in LPS-stimulated BV2 cells. Additionally, sterigmatocystins reduced nuclear translocation of NF- κ B. These results suggest that sterigmatocystins present in the fungal strain *Aspergillus* sp. are promising candidates for the treatment of neuroinflammatory diseases.

keywords: Antarctica; fungi metabolites; neuroinflammation; BV2 cells; sterigmatocystin; NF- κ B

4-36 *Biochemistry & Molecular Biology; Chemistry; Polymer Science*

Importance of rigidity of ice-binding protein (FfBP) for hyperthermal hysteresis activity and microbial survival

Hwang, Jisub., Kim, Bomi., Lee, Min Ju., Kim, Eun Jae., Cho, Sung Mi., Lee, Sung Gu., Han, Se Jong., Kim, Kitae., Lee, Jun Hyuck. and Do, Hackwon.

International Journal of Biological Macromolecules. 2022. 204: 485-499.

doi: 10.1016/j.ijbiomac.2022.02.032

Ice-binding proteins (IBPs) are well-characterized proteins responsible for the cold-adaptation mechanisms. Despite extensive structural and biological investigation of IBPs and antifreeze proteins, only a few studies have considered the relationship between protein stabilization and thermal hysteresis (TH) activity as well as the implication of hyperactivity. Here, we investigated the important role of the head

capping region in stabilization and the hyper-TH activity of FfBP using molecular dynamics simulation. Data comparison revealed that residues on the ice-binding site of the hyperactive FfBP are immobilized, which could be correlated with TH activity. Further comparison analysis indicated the disulfide bond in the head region is mainly involved in protein stabilization and is crucial for hyper-TH activity. This finding could also be generalized to known hyperactive IBPs. Furthermore, in mimicking the physiological conditions, bacteria with membrane-anchored FfBP formed brine pockets in a TH activity-dependent manner. Cells with a higher number of TH-active IBPs showed an increased number of brine pockets, which may be beneficial for short-and long-term survival in cold environments by reducing the salt concentration. The newly identified conditions for hyper-TH activity and their implications on bacterial survival provide insights into novel mechanistic aspects of cold adaptation in polar microorganisms.

keywords: Polar microorganisms; Ice binding proteins; Cold adaptation

4-37 *Pharmacology & Pharmacy*

Inhibitory Effect of RANKL-Induced Osteoclast Differentiation and ROS Generation by *Sphaerotylus antarcticus* Extract

Kim, Eun-Nam., Kang, Da Yeun., Trang, Nguyen Minh., Lee, Jun Hyuck., Ko, Young Wook., Kim, Sanghee. and 2 others.

Korean Journal of Pharmacognosy. 2022. 53(1): 42-48.

doi: 10.22889/KJP.2022.53.1.42

In order to maintain bone homeostasis, it is necessary to balance bone resorption and remodeling through the differentiation of osteoclasts that absorb old bone and osteoblasts that form new bone. However, bone resorption due to excessive osteoclast differentiation is a major cause of osteoporosis and controlling excessive osteoclast differentiation has been known as a treatment strategy for osteoporosis. Therefore, in this study, the effect of an ethanol extract of *Sphaerotylus antarcticus* Kirkpatrick, 1907 (SAE), polar-derived sponge with unknown biological activity, on the osteoclast differentiation process of RANKL-induced RAW264.7 cells and the generated ROS was evaluated. In the study results, SAE down-regulated the formation

and function of RANKL-induced osteoclasts and osteoclast differentiation specific proteins, genes in a concentration-dependent manner. In addition, it was possible to confirm the result of restoring the lost antioxidant enzyme along with down-regulation of ROS generated by RANKL. Therefore, in this study, we propose the possibility of SAE as a potential regulator of osteoporosis due to excessive osteoclast differentiation and report the biological value of the diversity of marine-derived natural products by identifying the first biological activity against SAE that is not yet known.

keywords: *S. antarcticus*; RANKL; RAW264.7; Osteoclast; Osteoporosis; ROS

4-38 Pharmacology & Pharmacy

The Interplay of Mycosporine-like Amino Acids between Phytoplankton Groups and Northern Krill (*Thysanoessa* sp.) in a High-Latitude Fjord (Kongsfjorden, Svalbard)

Kim, Bo Kyung., Park, Mi-Ok., Min, Jun-Oh., Kang, Sung-Ho., Shin, Kyung-Hoon., Yang, Eun Jin. and Ha, Sun-Yong.

Marine Drugs. 2022. 20(4).

doi: 10.3390/md20040238

We investigated pigment and mycosporine-like amino acid (MAA) concentrations of phytoplankton and Northern krill (*Thysanoessa* sp.) in sub-Arctic Kongsfjorden. Chlorophyll a (Chl-a) concentrations in the surface and middle-layer water were $0.44 \mu\text{g L}^{-1}$ ($\pm 0.17 \mu\text{g L}^{-1}$) and $0.63 \mu\text{g L}^{-1}$ ($\pm 0.25 \mu\text{g L}^{-1}$), respectively. Alloxanthin (Allo, a marker of cryptophytes) was observed at all stations, and its mean values for surface and middle-layer water were $0.09 \mu\text{g L}^{-1}$ ($\pm 0.05 \mu\text{g L}^{-1}$) and 0.05 ($\pm 0.02 \mu\text{g L}^{-1}$), respectively. The mean MAA-to-Chl-a ratios at the surface ($3.31 \pm 2.58 \mu\text{g} (\mu\text{g Chl-a})^{-1}$) were significantly higher than those in the middle-layer water ($0.88 \pm 0.49 \mu\text{g} (\mu\text{g Chl-a})^{-1}$), suggesting that these compounds play an important role in reducing UV photodamage. In gut pigment levels of Northern krill, the most abundant accessory pigment was Allo ($2.79 \pm 0.33 \mu\text{g g}^{-1}$ dry weight; d.w.), as was the accumulation of Chl-a ($8.29 \pm 1.13 \mu\text{g g}^{-1}$ d.w.). The average concentration of MAAs was $1.87 \mu\text{g g}^{-1}$ d.w. ($\pm 0.88 \mu\text{g g}^{-1}$ d.w.) in krill eyes, which was higher than that in all other body

parts ($0.99 \pm 0.41 \mu\text{g g}^{-1}$ d.w.), except for the gut. *Thysanoessa* sp. was found to contain five identified MAAs (shinorine, palythine, porphyra-334, mycosporine-glycine, and M-332) in the krill eye, whereas shinorine and porphyra-334 were only observed in the krill body, not the eyes and gut. These findings suggest that Northern krill accumulate MAAs of various compositions through the diet (mainly cryptophytes) and translocate them among their body parts as an adaptation for photoprotection and physiological demands.

keywords: pigment; mycosporine-like amino acids; phytoplankton; krill; Kongsfjorden; Svalbard

4-39 Biochemistry & Molecular Biology; Chemistry

Investigating the Functional Role of the Cysteine Residue in Dehydrin from the Arctic Mouse-Ear Chickweed *Cerastium arcticum*

Kim, Il-Sup., Choi, Woong., Park, Ae Kyung., Kim, Hyun., Son, Jonghyeon., Lee, Jun Hyuck., Shin, Seung Chul., Kim, T. Doohun. and Kim, Han-Woo.

Molecules. 2022. 27(9).

doi: 10.3390/molecules27092934

The stress-responsive, SK₅ subclass, dehydrin gene, *CaDHN*, has been identified from the Arctic mouse-ear chickweed *Cerastium arcticum*. *CaDHN* contains an unusual single cysteine residue (Cys143), which can form intermolecular disulfide bonds. Mutational analysis and a redox experiment confirmed that the dimerization of *CaDHN* was the result of an intermolecular disulfide bond between the cysteine residues. The biochemical and physiological functions of the mutant C143A were also investigated by in vitro and in vivo assays using yeast cells, where it enhanced the scavenging of reactive oxygen species (ROS) by neutralizing hydrogen peroxide. Our results show that the cysteine residue in *CaDHN* helps to enhance *C. arcticum* tolerance to abiotic stress by regulating the dimerization of the intrinsically disordered *CaDHN* protein, which acts as a defense mechanism against extreme polar environments.

keywords: dehydrin; Arctic mouse-ear chickweed; intermolecular disulfide bond; reactive oxygen species; dimerization; cysteine

The Longest Baseline Record of Vegetation Dynamics in Antarctica Reveals Acute Sensitivity to Water Availability

Colesie, Claudia., Pan, Yueming., Cary, S. Craig., Gemal, Emma., Brabyn, Lars., **Kim, Jeong-Hoon.** and 2 others.

Earths Future. 2022. 10(8).

doi: 10.1029/2022ef002823

Against a changing climate, the development of evidence-based and progressive conservation policies depends on robust and quantitative baseline studies to resolve habitat natural variability and rate of change. Despite Antarctica's significant role in global climate regulation, climate trend estimates for continental Antarctica are ambiguous due to sparse long-term *in situ* records. Here, we present the longest, spatially explicit survey of Antarctic vegetation by harmonizing historic vegetation mapping with modern remote sensing techniques. In 1961, E. D. Rudolph established a permanent survey plot at Cape Hallett, one of the most botanically diverse areas along the Ross Sea coastline, harboring all known types of non-vascular Antarctic vegetation. Following a survey in 2004 using ground-based photography, we conducted the third survey of Rudolph's Plot in 2018 using near-ground remote sensing and methodologies closely mirroring the two historic surveys to identify long-term changes and trends. Our results revealed that the vegetation at Cape Hallett remained stable over the past six decades with no evidence of transformation related to a changing climate. Instead, the local vegetation shows strong seasonal phenology, distribution patterns that are driven by water availability, and steady perennial growth of moss. Given that East Antarctica is at the tipping point of drastic change in the near future, with biological change having been reported at certain locations, this record represents a unique and potentially the last opportunity to establish a meaningful biological sentinel that will allow us to track subtle yet impactful environmental change in terrestrial Antarctica in the 21st century.

keywords: baseline environment; terrestrial ecosystem; climate change; Antarctica; remote sensing; moss

Low-temperature hydrogenation of nanodiamond as a strategy to fabricate sp^3 -hybridized nanocarbon as a high-performance persulfate activator

Gim, Gundu., Haider, Zeeshan., Suh, Sae-In., **Ahn, Yong-Yoon., Kim, Kitae.** and 4 others.

Applied Catalysis B-Environmental. 2022. 316.

doi: 10.1016/j.apcatb.2022.121589

This study presents the first instance of the application of hydrogenated nanodiamonds (H-NDs) for persulfate activation and the associated organic degradation. Surface hydrogenation at 600°C, confirmed by the increased surface density of the C-H moiety in XPS and FT-IR spectra, produced H-NDs that outperformed graphitized NDs (prepared via annealing at 1000°C) in terms of organic degradation and persulfate utilization efficiency. Hydrogenation improved the electrical conductivity of NDs; however, it was not accompanied by an increase in the sp^2 carbon content - in contrast to energy-intensive ND graphitization - resulting from sp^3 -to- sp^2 carbon transformation. In addition to the enhanced electron-transfer mediating activity, evidenced by the negative shift of the open circuit potential and current generation, isothermal titration calorimetry measurements indicated a significantly higher binding affinity of H-ND toward persulfate compared with that of graphitized ND. Multiple empirical results confirmed the progress of electron-transfer mediation as a major activation pathway.

keywords: Surface hydrogenation; Nanodiamond; Non-radical persulfate activation; Electron-transfer mediation; Surface binding affinity

Lucidumol A, Purified Directly from *Ganoderma lucidum*, Exhibits Anticancer Effect and Cellular Inflammatory Response in Colorectal Cancer

Shin, Min-Ji., Chae, Hae-Jung., Lee, Ji Won., **Koo, Man Hyung.,** Kim, Hyun-Jin., Seo, Jong Bae., Yanllia, Shagin., Park, Sang Hee., Lo, Han En., Kim, Sung-Hak., **Youn, Ui Joung.** and 2 others.

Evidence-Based Complementary and Alternative Medicine. 2022. 2022.

doi: 10.1155/2022/7404493

Colorectal cancer (CRC) is a deadly disease regardless of sex, and a few therapeutic approaches have been fully developed at advanced stages, even if some strategies have durable clinical benefits, such as immunotherapy and chemotherapy. *Ganoderma lucidum* has been recognized as an organism that suppresses tumors and inflammation; however, the molecular mechanisms induced by a triterpenoid in *Ganoderma lucidum*, Lucidumol A, have not yet been fully explored in CRC and inflammatory responses. To this end, we extracted Lucidumol A from *Ganoderma lucidum* and analyzed its anticancer effect and anti-inflammatory potential in CRC cell lines and RAW264.7 macrophage-derived cell lines, respectively. A series of *in vitro* experiments including cell survival, wound healing, and migration assays were performed to determine the role of Lucidumol A in the CRC cell line. We also analyzed inflammatory responses using qRT-PCR, Western Blot, and ELISA in RAW 264.7 macrophage-derived cell lines exposed to various concentrations of Lucidumol A. Lucidumol A efficiently suppressed the metastatic potential of CRC at very low concentrations. Furthermore, significant anti-inflammatory activities were observed in Lucidumol A-treated RAW264.7 cells through modulation of inflammation-associated marker genes and cytokines. In conclusion, Lucidumol A plays an important role in *Ganoderma lucidum*-dependent tumor suppression and anti-inflammation, suggesting different strategies to treat CRC patients, and other diseases evoked by proinflammatory cytokines, despite the need to explore further its mechanism of action.

contains gaps due to insertion or deletion events. Motivated by the measurement of information loss, we suggest assessment of the effective sequence length (ESL) of an aligned data set. The ESL can differ from the actual number of columns in a sequence alignment because of the presence of alignment gaps. Furthermore, the estimation of phylogenetic information is affected by model misspecification. Inevitably, the actual process of molecular evolution differs from the probabilistic models employed to describe this process. This disparity means the amount of phylogenetic information in an actual sequence alignment will differ from the amount in a simulated data set of equal size, which motivated us to develop a new test for model adequacy. Via theory and empirical data analysis, we show how to disentangle the effects of gaps and model misspecification. By comparing the Fisher information of actual and simulated sequences, we identify which alignment sites and tree branches are most affected by gaps and model misspecification. [Fisher information; gaps; insertion; deletion; indel; model adequacy; goodness-of-fit test; sequence alignment.]

4-43 Evolutionary Biology

Measuring Phylogenetic Information of Incomplete Sequence Data

Seo, Tae-Kun. and 2 others.

Systemic Biology. 2022. 71(3): 630-648.

doi: 10.1093/sysbio/syab073

Widely used approaches for extracting phylogenetic information from aligned sets of molecular sequences rely upon probabilistic models of nucleotide substitution or amino-acid replacement. The phylogenetic information that can be extracted depends on the number of columns in the sequence alignment and will be decreased when the alignment

4-44 Microbiology

A microbial driver of day mineral weathering and bioavailable Fe source under low-temperature conditions

Jung, Jaewoo., **Chung, Hyun Young.**, Ko, Youngtak., Moon, Inkyeong., Suh, Yeon Jee. and **Kim, Kitae.**

Frontiers in Microbiology. 2022. 13.

doi: 10.3389/fmicb.2022.980078

Biotic and abiotic Fe(III) reduction of clay minerals (illite IMt-1) under low-temperature (0 and 4°C, pH 6) was studied to evaluate the effects of bioalteration on soil properties including clay structure and elemental composition. The extent of Fe reduction in bioreduced samples (similar to 3.8% at 4°C and similar to 3.1% at 0°C) was lower than abiotic reduction (similar to 7.6%) using dithionite as a strong reductant. However, variations in the illite crystallinity value of bioreduced samples ($^{\circ}\Delta 2\theta = 0.580\text{-}0.625$) were greater than those of abiotic reduced samples ($^{\circ}\Delta 2\theta = 0.580\text{-}0.601$), indicating that modification of crystal structure is unlikely to have occurred in abiotic reduction. Moreover, precipitation of secondary-phase minerals

such as vivianite [$\text{Fe}^{2+}_3(\text{PO}_4)_2 \cdot 8\text{H}_2\text{O}$] and nano-sized biogenic silica were shown as evidence of reductive dissolution of Fe-bearing minerals that is observed only in a bioreduced setting. Our observation of a previously undescribed microbe-mineral interaction at low-temperature suggests a significant implication for the microbially mediated mineral alteration in Arctic permafrost, deep sea sediments, and glaciated systems resulting in the release of bioavailable Fe with an impact on low-temperature biogeochemical cycles.

keywords: microbe-mineral interaction; psychrophilic bacteria; biomineralization; Fe sources; illite (IMt-1)

4-45 Microbiology

Microbial metabolic responses and CO₂ emissions differentiated by soil water content variation in subarctic tundra soils

Kim, Dockyu., Chae, Namyi., **Kim, Mincheol.**, Nam, Sungjin., **Kim, Tai Kyoung.**, Park, Ki-Tea., Lee, Bang Yong., Kim, Eungbin. and **Lee, Hyoungeok.**

Journal of Microbiology. 2022. 60(12): 1130-1138.

doi: 10.1007/s12275-022-2378-3

Recent rapid air temperature increases across the northern-latitude tundra have prolonged permafrost thawing and snow melting periods, resulting in increased soil temperature (T-s) and volumetric soil water content (SWC). Under prolonged soil warming at 8°C, Alaskan tundra soils were incubated in a microcosm system and examined for the SWC differential influence on the microbial decomposition activity of large molecular weight (MW) humic substances (HS). When one microcosm soil (AKC1-1) was incubated at a constant SWC of 41% for 90 days (T = 90) and then SWC was gradually decreased from 41% to 29% for another T = 90, the initial HS was partly depolymerized. In contrast, in AKC1-2 incubated at a gradually decreasing SWC from the initial 32% to 10% for T = 90 and then increasing to 27% for another T = 90, HS depolymerization was undetected. Overall, the microbial communities in AKC1-1 could maintain metabolic activity at sufficient and constant SWC during the initial T = 90 incubation. In contrast, AKC1-2 microbes may have been damaged by drought stress during the drying SWC regimen, possibly resulting in the loss of HS decomposition activity, which did not recover even after re-wetting to an optimal SWC range (20-40%). After T = 90, the CO₂ production in both

treatments was attributed to the increased decomposition of small-MW organic compounds (including aerobic HS-degradative products) within an optimal SWC range. We expect this study to provide new insights into the early effects of warming- and topography-induced SWC variations on the microbial contribution to CO₂ emissions via HS decomposition in northern-latitude tundra soil.

keywords: Arctic tundra soil; CO₂ emission; global warming; microbial decomposition; soil organic matter

4-46 Life Sciences & Biomedicine - Other Topics

Molecular Diet Analysis of Adelie Penguins (*Pygoscelis adeliae*) in the Ross Sea Using Fecal DNA

Tabassum, Nazia., Lee, Ji-Hyun., Lee, Soo-Rin., **Kim, Jong-U.**, Park, Hyun., Kim, Hyun-Woo. and **Kim, Jeong-Hoon.**

Biology-Basel. 2022. 11(2).

doi: 10.3390/biology11020182

The diet of Adélie penguins, *Pygoscelis adeliae*, is a useful indicator in understanding the ecological conditions of their habitats. The diets of Adelie penguins were studied using metabarcoding and quantitative PCR (qPCR) analyses of fecal DNA from seven habitats along the Ross Sea region. Using metabarcoding analysis with dual universal primers (18Sv9 and miniFish), the overall diet composition and detailed information about piscine prey were clearly elucidated. It was found that two krill species (*Euphausia superba* and *Euphausia crystallorophias*) and notothenioid fish were the most abundant in the diets of Adélie penguins. Among the notothenioid prey, *Pleuragramma antarctica* (56.50%) and *Pagothenia borchgrevinki* (18.21%) were the two most abundant species. qPCR analysis showed a significant geographic difference in the composition of main prey. Penguins inhabiting outbound parts of the Ross Sea (Capes Adare (CA) and Duke of York Island (DY)) mainly preyed on *E. superba*, without any significant changes in prey composition. By contrast, those inhabiting the inbound parts of the Ross Sea (Edmonson Point (EP) and Inexpressible Island (II)) preyed on *E. crystallorophias* and notothenioid fish rather than *E. superba*. Compared with the outbound habitats, prey compositions for penguins inhabiting the inbound regions were significantly different year to year, which was presumably due to the food availability based on

the annual environmental and meteorological conditions of the coastal region along with the inbound parts of the Ross Sea.

keywords: *Pygoscelis adeliae*; Ross Sea; NGS; metabarcoding; diet analysis

4-47 *Biochemistry & Molecular Biology; Pharmacology & Pharmacy; Chemistry*

Non-peptide secondary metabolites from poisonous mushrooms: overview of chemistry, bioactivity, and biosynthesis

Lee, Seulah. and 3 others.

Natural Product Reports. 2022. 39(3): 512-559.

doi: 10.1039/d1np00049g

A wide variety of mushrooms have traditionally been recognized as edible fungi with high nutritional value and low calories, and abundantly produce structurally diverse and bioactive secondary metabolites. However, accidental ingestion of poisonous mushrooms can result in serious illnesses and even death. Chemically, mushroom poisoning is associated with secondary metabolites produced in poisonous mushrooms, causing specific toxicity. However, many poisonous mushrooms have not been fully investigated for their secondary metabolites, and the secondary metabolites of poisonous mushrooms have not been systematically summarized for details such as chemical composition and biosynthetic mechanisms. The isolation and identification of secondary metabolites from poisonous mushrooms have great research value since these compounds could be lethal toxins that contribute to the toxicity of mushrooms or could provide lead compounds with remarkable biological activities that can promote advances in other related disciplines, such as biochemistry and pharmacology. In this review, we summarize the structures and biological activities of secondary metabolites identified from poisonous mushrooms and provide an overview of the current information on these metabolites, focusing on their chemistry, bioactivity, and biosynthesis.

4-48 *Microbiology*

Novel, acidic, and cold-adapted glycoside hydrolase family 8 endo- β -1,4-glucanase from an Antarctic lichen-associated bacterium, *Lichenicola cladoniae* PAMC 26568

Kim, Do Young., Kim, Jonghoon., **Lee, Yung Mi.** and 5 others.

Frontiers in Microbiology. 2022. 13.

doi: 10.3389/fmicb.2022.935497

Endo- β -1,4-glucanase is a crucial glycoside hydrolase (GH) involved in the decomposition of cellulosic materials. In this study, to discover a novel cold-adapted β -1,4-D-glucan-degrading enzyme, the gene coding for an extracellular endo- β -1,4-glucanase (GluL) from *Lichenicola cladoniae* PAMC 26568, an Antarctic lichen (*Cladonia borealis*)-associated bacterium, was identified and recombinantly expressed in *Escherichia coli* BL21. The GluL gene (1044-bp) encoded a non-modular polypeptide consisting of a single catalytic GH8 domain, which shared the highest sequence identity of 55% with that of an uncharacterized protein from *Gluconacetobacter takamatsuzukensis* (WP_182950054). The recombinant endo- β -1,4-glucanase (rGluL: 38.0 kDa) most efficiently degraded sodium carboxymethylcellulose (CMC) at pH 4.0 and 45 degrees C, and showed approximately 23% of its maximum degradation activity even at 3°C. The biocatalytic activity of rGluL was noticeably enhanced by >1.3-fold in the presence of 1 mM Mn^{2+} or NaCl at concentrations between 0.1 and 0.5 M, whereas the enzyme was considerably downregulated by 1 mM Hg^{2+} and Fe^{2+} together with 5 mM *N*-bromosuccinimide and 0.5% sodium dodecyl sulfate. rGluL is a true endo- β -1,4-glucanase, which could preferentially decompose D-cellooligosaccharides consisting of 3 to 6 D-glucose, CMC, and barley beta-glucan, without other additional glycoside hydrolase activities. The specific activity (15.1 U mg^{-1}) and k_{cat}/K_m value ($6.35 \text{ mg}^{-1} \text{ s}^{-1} \text{ mL}$) of rGluL toward barley β -glucan were approximately 1.8- and 2.2-fold higher, respectively, compared to its specific activity (8.3 U mg^{-1}) and k_{cat}/K_m value ($2.83 \text{ mg}^{-1} \text{ s}^{-1} \text{ mL}$) toward CMC. The enzymatic hydrolysis of CMC, D-cellootetraose, and D-cellohexaose yielded primarily D-cellobiose, accompanied by D-glucose, D-cellobiose, and D-cellootetraose. However, the cleavage of D-cellopentaose by rGluL resulted in the production of only D-cellobiose and D-cellobiose. The findings of the present study imply that rGluL is a novel, acidic, and cold-adapted GH8 endo- β -1,4-glucanase with high

specific activity, which can be exploited as a promising candidate in low-temperature processes including textile and food processes.

keywords: endo- β -14-glucanase; glycoside hydrolase; GH8; cold-adapted enzyme; Antarctica; lichen-associated bacterium; *Lichenicola cladoniae*

4-49 *Environmental Sciences & Ecology; Public, Environmental & Occupational Health*

Physiological and molecular responses of the Antarctic harpacticoid copepod *Tigriopus kingsejongensis* to salinity fluctuations-A multigenerational study

Kim, Bo-Mi., Lee, Yeonhui., Hwang, Jhee-Yeong., Kim, Young-Ki., Kim, Tae Wan., Kim, Il-Nam., Kang, Seunghyun., Kim, Jin-Hyoung. and Rhee, Jae-Sung.

Environmental Research. 2022. 204.

doi: 10.1016/j.envres.2021.112075

Since Antarctica and the surrounding Southern Ocean are facing global climate change, biota inhabiting those coastal regions is now challenged by environmental fluctuations including coastal freshening. In this study, the effects of salinity range of 0-75 (practical salinity unit, PSU) on the Antarctic harpacticoid copepod *Tigriopus kingsejongensis* was investigated by measurement of 96 h survival rate, lifespan, and sex ratio with further analysis of multigenerational growth parameters and mRNA expressions under salinity of 15-45. Different stages of the copepods (i.e., nauplius, male, and female) generally showed tolerance to hypo- and hypersalinity, wherein female copepods were more tolerant than males when exposed to salinity fluctuations. Lifespan was significantly shortened by hypo- and hypersalinity compared to control salinity (34), but there was no significant difference in the sex ratio between salinity treatments. Multigenerational experiments across five generations revealed that exposure to salinities of 15 and 45 reduced body length compared to that in control salinity and the first generation of each salinity group. Our results provide evidence regarding *T. kingsejongensis* on their preferred salinity ranges, physiological limit to salinity fluctuations, and population dynamics in future salinity.

keywords: Antarctic freshening; Hyposalinity; Hypersalinity; Salinity tolerance; Osmoregulation; Multigeneration

4-50 *Microbiology*

Polymorphobacter megasporae sp. nov., isolated from an Antarctic lichen

Noh, Hyun-Ju., Park, Yerin., Yang, Junwon., Jang, Seonghan., Lee, Hyoungseok. and Lee, Yung Mi.

International Journal of Systematic and Evolutionary Microbiology. 2022. 72(9).

doi: 10.1099/ijsem.0.005535

A Gram-stain-negative, aerobic, orange-coloured, rod-shaped and non-motile bacterial strain, PAMC 29362^T, was isolated from an Antarctic lichen, *Megaspora verrucosa*. Phylogenetic and phylogenomic analyses indicated that strain PAMC 29362^T belongs to the genus *Polymorphobacter* and was most closely related to *Polymorphobacter arshaanensis* (97.0% of 16S rRNA gene similarity), *Polymorphobacter fuscus* (96.3%), *Polymorphobacter multimanifer* (95.3%) and *Polymorphobacter glacialis* (95.2%). Genomic relatedness analyses showed that strain PAMC 29362^T is clearly distinguished from type strains of the genus *Polymorphobacter* based on values of average nucleotide identity (<74.3%) and digital DNA-DNA hybridization (<20.4%). The genomic DNA G+C content of PAMC 29362^T was 65.5%. The major fatty acids (>10%) were summed feature 8 (C_{18:1} ω 7c; 38.5%) and summed feature 3 (C_{16:1} ω 7c and/or C_{16:1} ω 6c; 31.5%). The major respiratory quinone was Q-10. Based on the results of phylogenetic, genome-based relatedness and physiological analyses, strain PAMC 29362^T is proposed to represent a novel species of the genus *Polymorphobacter*, with the name *Polymorphobacter megasporae* sp. nov. The type strain is PAMC 29362^T (=KCTC 82578^T =JCM 34545^T).

keywords: Antarctica; novel species; *Polymorphobacter megasporae*; polyphasic taxonomy; lichen

4-51 *Biotechnology & Applied Microbiology; Microbiology*

Production and Characterization of a Recombinant Cold-Active Acetyl Xylan Esterase from Psychrophilic *Paenibacillus* sp. R4 Strain

Dieu Linh, Nguyen., Hwang, Jisub., Kim, Eun Jae., Lee, Jun Hyuck. and Han, Se Jong.

Applied Biochemistry and Microbiology. 2022. 58(4): 428-434.

doi: 10.1134/s0003683822040123

Acetyl xylan esterases (AXEs) hydrolyze the specific ester linkages between acetic acid and xylose units, leading to the deacetylation and depolymerization of xylan. The AXE from the soil-psychrophilic *Paenibacillus* sp. R4 strain (PbAcE), was produced in recombinant *Escherichia coli* with 1 mM isopropyl β -D-1-thiogalactopyranoside. The final dry cell weight and production of purified PbAcE were 17 g/L and 657 mg/L using 7-L bioreactor and, 6 g/L and 500 mg/L using 30-L fermenter, respectively. The hydrolysis activity of PbAcE was approximately 27 U/mg when *p*-nitrophenyl was used as the substrate. PbAcE was the most active at pH 8.0 and it maintained more than 80% activity from pH 4.0 to pH 11.0 compared to the maximum value under the given conditions. Furthermore, PbAcE deacetylated cephalothin and chromomycin A₃ antibiotics. The current study demonstrates that the production of PbAcE was successful, and the results may encourage further application studies.

keywords: cold-active acetyl xylan esterase; *Paenibacillus* sp.; R4; carbohydrate esterase 7; *Escherichia coli*; IPTG induction; antibiotic modification

4-52 Life Sciences & Biomedicine - Other Topics

Production, Purification, and Characterization of *Phaseolus vulgaris* Leghemoglobin *a* in *Pichia pastoris*

Kim, Jun-Young., Han, Da-Hee., Park, Geun-o., Nam, Soo-Wan., Kim, Yeon-Hee., **Kim, Han-Woo.** and Jun, Sung-Jong.

Microbiology and Biotechnology Letters. 2022. 50(4): 508-511.

doi: 10.48022/mbi.2211.11001

In this study, *Phaseolus vulgaris* (kidney bean) leghemoglobin *a* (PhLba) gene was cloned into pPICZαA and expressed in *Pichia pastoris* to sustainably produce a heme-carrying protein for organoleptic use in plant-based meat. The recombinant PhLba protein was secreted into the culture medium in a solubilized form, and the molecular weight of the purified PhLba was estimated to be 16.5 kDa using SDS-PAGE. In addition, the yield of recombinant PhLba holoprotein was enhanced by supplementation of the cultivation medium with hemin. This result indicates that the apo-forms of PhLba can be effectively saturated with cofactor.

keywords: Leghemoglobin; heme; cofactor; *Phaseolus vulgaris*; *Pichia pastoris*

4-53 Materials Science

Purification and Characterization of a New Cold-active Cellulolytic Enzyme Produced by *Pseudoalteromonas* sp. ArcC09 from the Arctic Beaufort Sea

Kim, Min Ju., Park, Ha Ju., Kang, Pilsung., Kim, Il Chan., Yim, Joung Han. and Han, Se Jong.

Bioresources. 2022. 17(2): 3163-3177.

doi: 10.15376/biores.17.2.3163-3177

A cold-active endoglucanase-producing bacterium was isolated from the Beaufort Sea of the Arctic Ocean and identified as *Pseudoalteromonas* sp. ArcC09. Cellulolytic activity of ArcC09 reached a maximum of 60 U/mg when cultivated in ZoBell medium for 72 h at 15 °C. This purified endoglucanase, with a molecular mass of 28 kDa, exhibited maximum activity at pH 7.0 and 55 °C. The ArcC09 endoglucanase exhibited 10% and 36% of its maximal activity even at low temperatures of 5 °C and 15 °C, respectively. However, it showed lower thermal stability than a mesophilic cellulase, which is characteristic of a psychrophilic enzyme. The activity was inhibited by CuSO₄, and linear alkylbenzene sulfonate (LAS). These findings supplement the understanding of cold-active endoglucanases and may have commercial applications in enzymatic digestion of cellulosic biomass to fermentable sugars.

keywords: Arctic bacterium; Cellulolytic enzyme; Cold-active; *Pseudoalteromonas*; Purification

4-54 Biochemistry & Molecular Biology; Chemistry

Recognition mechanism of endocellulase for β -glucan containing $\beta(1 \rightarrow 3)$, $(1 \rightarrow 4)$ mixed-linkages

Kataoka, Misumi., **Kim, Han-Woo.** and Ishikawa, Kazuhiko. *Carbohydrate Research*. 2022. 522.

doi: 10.1016/j.carres.2022.108682

Glycoside hydrolase family 12 endocellulase (GH family12) plays a key role in the degradation of β -glucan and cellulose. Hyperthermostable GH family

12 endocellulase from the archaeon *Pyrococcus furiosus* (EGPf) catalyzes the hydrolysis of $\beta(1 \rightarrow 4)$ glucosidic linkages in cellulose and β -glucan containing $\beta(1 \rightarrow 3)$, $(1 \rightarrow 4)$ mixed linkages. Therefore, in the combination with the hyperthermophilic β -glucosidase from *P. furiosus* (BGLPf), non-crystalline cellulose and β -glucan can be degraded to glucose completely by EGPf at high temperature. X-ray crystallography and protein engineering were used to reveal how the $\beta(1 \rightarrow 4)$ and $\beta(1 \rightarrow 3)$ linkages in β -glucan substrates are recognized by the enzyme. Structural and functional analyses clarified that the active site of EGPf consists of six subsites: the reducing end subsites (+1 and +2) recognize both $\beta(1 \rightarrow 4)$ and $\beta(1 \rightarrow 3)$ linkages of various substrates in a productive binding mode, and recognition is controlled by Trp121 and Gln208 located at subsite +2. It was also revealed that the deep cleft in subsite -4 can accommodate the torsion angles of substrates consisting of $\beta(1 \rightarrow 3)$, $(1 \rightarrow 4)$ mixed-linkages due to the changing tilt of the Trp62 side chain. From the structural similarity, it is proposed that the substrate specificity of family 12 endocellulases towards $\beta(1 \rightarrow 3)$, $(1 \rightarrow 4)$ mixed-linkage substrates are controlled by the subsites (+1, +2, and -4). Furthermore, the function of family 12 endocellulase could be improved by protein engineering method using the information of the analysis.

keywords: Biomass; Hyperthermophile; Archaea; *Pyrococcus*; Glycoside hydrolase; Cellulase; β -Glucan; X-ray crystallography; Protein engineering

4-55 Engineering; Environmental Sciences & Ecology

Reductive Transformation of Hexavalent Chromium in Ice Decreases Chromium Toxicity in Aquatic Animals

Kim, Bo-Mi., Kim, Bomi., Nam, Sang-Eun., Eom, Hye-Jin., Lee, Somyeong., Kim, Kitae. and Rhee, Jae-Sung.

Environmental Science & Technology. 2022. 56(6): 3503-3513.

doi: 10.1021/acs.est.1c07336

In this study, the toxicity of hexavalent chromium [Cr(VI)] reduced by citric acid in ice was measured using representative aquatic model invertebrates (*i.e.*, rotifer, water flea, amphipod, and polychaete) and a vertebrate (zebrafish) by analyzing short- and/or long-term endpoints that are frequently applied to

each animal. Cr(VI) reduction in the presence of citric acid was markedly enhanced in the ice phase compared to that in an aqueous solution through the freeze concentration effect. The highly concentrated Cr(VI) and citric acid in ice grain boundaries were also confirmed using *in situ* cryogenic confocal Raman spectroscopy. Overall, exposure to Cr(VI) resulted in higher acute and/or chronic effects on aquatic animals, such as drastic mortality, growth inhibition, and decrease in offspring number, whereas the animals were increasingly tolerant to Cr(VI) that was reduced in the ice phase. Sublethal concentrations of Cr(VI) significantly decreased the antioxidant capacity in the aquatic animals. However, when the same concentrations of Cr(VI) were reduced in ice, these treatments showed no modulation or increase in the antioxidant defense system. Taken together, our results suggest that Cr(VI) reduction into Cr(III) was successfully achieved in ice and that this methodology can decrease the actual toxicity of Cr(VI) in aquatic animals.

keywords: chromium toxicity; chromium reduction; aquatic animal; toxicity endpoint; chemical reaction in ice

4-56 Biotechnology & Applied Microbiology

Safety evaluation of mycotoxin citrinin production from *Monascus ruber* through whole-genome sequencing and analytical evaluation

Yoon, Hye Ree., Ku, Danyeol., Han, Suk., Shin, Seung Chul., Kim, Han-Woo. and Kim, Hyo Jin.

3 Biotech. 2022. 12(9).

doi: 10.1007/s13205-022-03287-z

In this study, the whole genome of *Monascus ruber* KACC 46666 was generated using the PacBio RSII sequencer with high-quality de novo assembly to obtain trustworthy assembly and annotation using genome assemblies with long reads from PacBio single-molecule real-time sequencing. The whole genome of *M. ruber* has a total length of 25.9 Mb, divided in 13 contigs with 9639 genes. The functions of genes involved in secondary metabolite production were further analyzed. Gene clusters involved in the production of *Monascus* pigment, monacolin K, and mycotoxin citrinin were identified. Notably, most of the citrinin gene cluster was lost, as confirmed via high-performance liquid chromatography analysis.

This genome-level safety evaluation of industrially important *Monascus* strains will provide valuable information for genome-based microbial engineering of natural food colorants and production of commercially important secondary metabolites such as monacolin K.

keywords: *Monascus ruber*; Whole-genome sequencing; Citrinin; Fungal metabolites

4-57 Life Sciences & Biomedicine - Other Topics

Soil properties and molecular compositions of soil organic matter in four different Arctic regions

Jeong, Sujeong., Nam, Sungjin. and Jung, Ji Young.

Journal of Ecology and Environment. 2022. 46(4): 282-291.

doi: 10.5141/jee.22.069

Background: The Arctic permafrost stores enormous amount of carbon (C), about one third of global C stocks. However, drastically increasing temperature in the Arctic makes the stable frozen C stock vulnerable to microbial decomposition. The released carbon dioxide from permafrost can cause accelerating C feedback to the atmosphere. Soil organic matter (SOM) composition would be the basic information to project the trajectory of C under rapidly changing climate. However, not many studies on SOM characterization have been done compared to quantification of SOM stocks. Thus, the purpose of our study is to determine soil properties and molecular compositions of SOM in four different Arctic regions. We collected soils in different soil layers from 1) Cambridge Bay, Canada, 2) Council, Alaska, USA, 3) Svalbard, Norway, and 4) Zackenberg, Greenland. The basic soil properties were measured, and the molecular composition of SOM was analyzed through pyrolysis- gas chromatography/mass spectrometry (py-GC/MS).

Results: The Oi layer of soil in Council, Alaska showed the lowest soil pH and the highest electrical conductivity (EC) and SOM content. All soils in each site showed increasing pH and decreasing SOC and EC values with soil depth. Since the Council site was moist acidic tundra compared to other three dry tundra sites, soil properties were distinct from the others: high SOM and EC, and low pH. Through the py-GC/MS analysis, a total of 117 pyrolysis products were detected from 32 soil samples of four different Arctic soils. The first two-axis of the PCA explained 38% of sample variation.

While short- and mid-hydrocarbons were associated with mineral layers, lignins and polysaccharides were linked to organic layers of Alaska and Cambridge Bay soil.

Conclusions: We conclude that the py-GC/MS results separated soil samples mainly based on the origin of SOM (plants- or microbially-derived). This molecular characteristics of SOM can play a role of controlling SOM degradation to warming. Thus, it should be further investigated how the SOM molecular characteristics have impacts on SOM dynamics through additional laboratory incubation studies and microbial decomposition measurements in the field.

keywords: soil organic matter (SOM); Arctic soil; pyrolysis-GC/MS; soil physical and chemical properties; chemical characterization of SOM

4-58 Biochemistry & Molecular Biology

Stereocalpin B, a New Cyclic Depsipeptide from the Antarctic Lichen *Ramalina terebrata*

Lee, Seulah., Jeong, Se Yun., Dieu Linh, Nguyen., So, Jae Eun., Kim, Ki Hyun., Kim, Ji Hee., Han, Se Jong., Suh, Sung-Suk., Lee, Jun Hyuck. and Youn, Ui Joung.

Metabolites. 2022. 12(2).

doi: 10.3390/metabo12020141

Stereocalpin B, a new cyclic depsipeptide (1), and a new dibenzofuran derivative (3), were isolated from the Antarctic lichen, *Ramalina terebrata* (Ramalinaceae), along with a known cyclic depsipeptide (2). The structures of new compounds were characterized by comprehensive spectrometric analyses; high-resolution fast atom bombardment mass spectrometry (HR-FABMS) and liquid chromatography-tandem mass spectrometry (LC-MS/MS). Stereocalpin B (1) existed in a rotameric equilibrium, which was confirmed using nuclear Overhauser effect spectroscopy (NOESY)/exchange spectroscopy (EXSY) spectrum. Absolute configurations of the amino acid units in 1 were assigned using the advanced Marfey's method and subsequent NOESY analysis of the 5-hydroxy-2,4-dimethyl-3-oxo-decanoic acid residue confirmed the complete stereochemistry of 1. Compounds 1-3 exhibited moderate antimicrobial activities against *E. coli*, with the IC₅₀ values ranging from 18-30 µg/mL. Compound 2 exhibited cell growth inhibition against HCT116 cell lines, with the IC₅₀ value of 20±1.20 µM,

and compounds 1 and 2 also showed potent anti-inflammatory activities against lipopolysaccharide (LPS)-induced RAW264.7 macrophages with the IC₅₀ values ranging from 5–7 μ M.

keywords: *Ramalina terebrata*; cyclic depsipeptides; dibenzofuran; antimicrobial; cytotoxicity; anti-inflammation

4-59 *Biochemistry & Molecular Biology; Biophysics*

Structural basis for the substrate specificity of an S-formylglutathione hydrolase derived from *Variovorax* sp. PAMC 28711

Hwang, Jisub., Kim, Bogeun., Lee, Min Ju., Nam, Yewon., Youn, Ui Joung., Lee, Chang Sup., Oh, Tae-Jin., Park, Hyun Ho., **Do, Hackwon.** and **Lee, Jun Hyuck**

Biochemical and Biophysical Research Communications. 2022. 629: 159–164.

doi: 10.1016/j.bbrc.2022.09.008

S-Formylglutathione hydrolase was originally known to catalyze the hydrolysis of S-formylglutathione to formate and glutathione. However, this enzyme has a broader esterase activity toward substrates containing thioester and ester bonds. In a previous study, we identified a new S-formylglutathione hydrolase (VaSFGH) gene in the Antarctic bacterium *Variovorax* sp. PAMC 28711, and recombinant VaSFGH protein was purified and characterized. Previous enzyme activity assays showed that VaSFGH has high activity, especially toward short-chain *p*-nitrophenyl esters (C2–C4). In this study, we determined the crystal structure of substrate-free VaSFGH at a resolution of 2.38 Å. In addition, *p*-nitrophenyl ester-bound VaSFGH structure models were generated by molecular docking simulations to obtain structural evidence of its substrate specificity. Comparative structural analysis of the apo-form and *p*-nitrophenyl ester-bound VaSFGH model structures revealed that large substrates could not bind inside the hydrophobic substrate-binding pocket because of the intrinsically static and relatively small substrate-binding pocket size of VaSFGH. This study provides useful information for further protein engineering of SFGHs for industrial use.

keywords: Crystal structure; S-Formylglutathione hydrolase; Substrate specificity; *Variovorax* sp; PAMC 28711; X-ray crystallography

4-60 *Microbiology*

Temperature sensitivity of Antarctic soil-humic substance degradation by cold-adapted bacteria

Kim, Dockyu., Park, Ha Ju., Kim, Mincheol., Lee, Seulah., Hong, Soon Gyu., Kim, Eungbin. and **Lee, Hyoungseok**

Environmental Microbiology. 2022. 24(1): 265–275.

doi: 10.1111/1462-2920.15849

Heteropolymer humic substances (HS) are the largest constituents of soil organic matter and are key components that affect plant and microbial growth in maritime Antarctic tundra. We investigated HS decomposition in Antarctic tundra soils from distinct sites by incubating samples at 5°C or 8°C (within a natural soil thawing temperature range of –3.8°C to 9.6°C) for 90 days (average Antarctic summer period). This continuous 3-month artificial incubation maintained a higher total soil temperature than that in natural conditions. The long-term warming effects rapidly decreased HS content during the initial incubation, with no significant difference between 5°C and 8°C. In the presence of Antarctic tundra soil heterogeneity, the relative abundance of *Proteobacteria* (one of the major bacterial phyla in cold soil environments) increased during HS decomposition, which was more significant at 8°C than at 5°C. Contrasting this, the relative abundance of *Actinobacteria* (another major group) did not exhibit any significant variation. This microcosm study indicates that higher temperatures or prolonged thawing periods affect the relative abundance of cold-adapted bacterial communities, thereby promoting the rate of microbial HS decomposition. The resulting increase in HS-derived small metabolites will possibly accelerate warming-induced changes in the Antarctic tundra ecosystem.

4-61 *Biodiversity & Conservation; Environmental Sciences & Ecology*

Trophic relations based on fecal DNA in tundra terrestrial food webs near Kongsfjorden, Svalbard, Norway

Kim, Jihee., **Lee, Won Young.** and Park, Sangkyu.

Polar Biology. 2022. 45(4): 615–625.

doi: 10.1007/s00300-022-03022-7

For the conservation and management of the Arctic regions vulnerable to climate change, it is important to elucidate the trophic relations and food sources for consumers in the ecosystems. We analyzed DNA extracted from feces to understand the summer diets of the major terrestrial animals and their trophic relations in tundra ecosystems near Kongsfjorden, Svalbard. Feces of Svalbard reindeer (*Rangifer tarandus platyrhynchus*), Barnacle Goose (*Branta leucopsis*), Arctic fox (*Vulpes lagopus*), and Rock Ptarmigan (*Lagopus muta*) were collected during the summer seasons of 2014, 2015, 2018, and 2019. Plant DNA was detected in the feces of herbivores (reindeer, goose, and ptarmigan) and vertebrate DNA was detected in the feces of carnivore (Arctic fox) by amplifying, cloning, and Sanger sequencing. In case of Arctic fox, *VulpesB*, the blocking primer preventing from amplifying Arctic fox DNA, was used to improve the detection of their prey DNA. *Salix* was the most detected genus in feces of Svalbard reindeer and Barnacle Goose, which were described as feeding on graminoids, forbs, and prostrate as well as bryophyte. Bryophyte was added as an important food source for all herbivores. Arctic fox preferred birds such as geese (Anatidae) and gulls (Laridae), showing that interpretation between Arctic foxes and gulls may have occurred at the same predator level. Our results suggest that cloning-based DNA analysis using fecal sample contributes to understanding the tundra terrestrial food web near Kongsfjorden.

keywords: Arctic food webs; Arctic fox; Barnacle Goose; Fecal dietary analysis; Svalbard reindeer; Svalbard

subjected to the fractionation by solvent partition, and the CH₂Cl₂ fraction was analyzed for the isolation of bioactive compounds, aided by an untargeted liquid chromatography mass spectrometry (LC-MS)-based analysis. Through chemical analysis, five fatty acid derivatives (**1-5**), including two new fatty acid derivatives, omphalotols A and B (**1** and **2**), were isolated from the CH₂Cl₂ fraction, and the chemical structures of the new compounds were determined using 1D and 2D nuclear magnetic resonance (NMR) spectroscopy and high resolution electrospray ionization mass spectrometry (HR-ESIMS), as well as fragmentation patterns in MS/MS data and chemical reactions followed by the application of Snatzke's method and competing enantioselective acylation (CEA). In the anti-*Helicobacter pylori* activity test, compound **1** showed moderate antibacterial activity against *H. pylori* strain 51 with 27.4% inhibition, comparable to that of quercetin as a positive control. Specifically, compound **3** exhibited the most significant antibacterial activity against *H. pylori* strain 51, with MIC₅₀ and MIC₉₀ values of 9 and 20 µM, respectively, which is stronger inhibitory activity than that of another positive control, metronidazole (MIC₅₀ = 17 µM and MIC₉₀ = 46 µM). These findings suggested the experimental evidence that the compound **3**, an α,β-unsaturated ketone derivative, could be used as a moiety in the development of novel antibiotics against *H. pylori*.

keywords: Omphalotus japonicus; Marasmiaceae; fatty acid derivatives; LC-MS; MS; anti-H; pylori activity

4-62 Pharmacology & Pharmacy

Two New Fatty Acid Derivatives, Omphalotols A and B and Anti-*Helicobacter pylori* Fatty Acid Derivatives from Poisonous Mushroom *Omphalotus japonicus*

Lee, Seulah. and 7 others.

Pharmaceuticals. 2022. 15(2).

doi: 10.3390/ph15020139

As part of ongoing systematic research into the discovery of bioactive secondary metabolites with mushroom, *Omphalotus japonicus* (Kawam.) Kirchm. & O. K. Mill. belonging to the family Marasmiaceae, which causes nausea and vomiting after consumption. The methanolic extract of *O. japonicus* fruiting bodies was

4-63 Environmental Sciences & Ecology

Using seabird and whale distribution models to estimate spatial consumption of krill to inform fishery management

V. Warwick-Evans., N. Kelly., L. Dalla Rosa., A. Friedlaender., J. T. Hinke., Kim, Jeong-Hoon. and 5 others.

Ecosphere. 2022. 13(6).

doi: 10.1002/ecs2.4083

Ecosystem dynamics at the northwest Antarctic Peninsula are driven by interactions between physical and biological processes. For example, baleen whale populations are recovering from commercial harvesting against the backdrop of rapid climate change, including reduced sea ice extent and changing ecosystem composition. Concurrently, the

commercial harvesting of Antarctic krill is increasing, with the potential to increase the likelihood for competition with and between krill predators and the fishery. However, understanding the ecology, abundance, and spatial distribution of krill predators is often limited, outdated, or at spatial scales that do not match those desired for effective fisheries management. We update current knowledge of predator dependence on krill by integrating telemetry-based data, at-sea observational surveys, estimates of predator abundance, and physiological data to estimate the spatial distribution of krill consumption during the austral summer by three species of *Pygoscelis* penguin, 11 species of flying seabirds, one species of pinniped, and two species of baleen whale. Our models show that the majority of important areas for krill predator foraging are close to penguin breeding colonies in nearshore areas where humpback whales also regularly feed, and along the shelf-break, though we caution that not all known krill predators are included in these analyses. We show that krill consumption is highly variable across the region, and often concentrated at fine spatial scales, emphasizing the need for the management of the local krill fishery at relevant temporal and spatial scales. We also note that krill consumption by recovering populations of krill predators provides further evidence in support of the krill surplus hypothesis, and highlight that despite less than comprehensive data, cetaceans are likely to consume a significant proportion of the krill consumed by natural predators but are not currently considered directly in the management of the krill fishery. If management of the krill fishery is to be precautionary and operate in a way that minimizes the risks to krill predator populations, it will be necessary in future analyses, to include up-to-date and precise abundance and consumption estimates for pack-ice seals, finfish, squid, and other baleen whale species not currently considered.

keywords: Antarctic ecosystem; ecosystem approach; hfisheries management; habitat modeling; humpback whales; penguins; seabirds; spatial ecology

4-64 *Materials Science; Physics*

Visible Light Illumination Effects on Instability of MoS₂ Thin-Film Transistors for Optical Sensor Application

Seo, Seung Gi., Ryu, Jae Hyeon., **Lee, Won Young.** and Jin, Sung Hun.

Physica Status Solidi a-Applications and Materials Science. 2022. 219(7).

doi: 10.1002/pssa.202200052

With the advent of the trillion sensor era, molybdenum disulfide (MoS₂) offers intriguing future optical device opportunities due to qualities such as its novel optoelectronic properties and preferable form factors. However, while a fundamental understanding of device reliability under illumination is significantly important, most of the previous research has focused on persistent photocurrent (PPC) effects. For this reason, understanding of a clear mechanism remains elusive. Herein the work reported, electrical-bias-dependent device instability and net optical illumination effects of MoS₂ thin-film transistors (TFTs) are experimentally evaluated to decouple the origins of device instability coming from either net electrical bias stress or illumination stress. In addition, time-dependent monitoring of relaxation behaviors under illumination at different wavelength hints that excess carrier generation and remnant electrons after annihilation during illumination play a key role in determination of photo-initiated instability of a device. For practical suppression of device instability under ambient light, an operation scheme (using trapping time increase under positive bias) is adroitly utilized to provide reliable device performance. Systematic understanding of device instability of MoS₂ TFTs, and of their suppression principles, is potentially beneficial for the design of next-generation devices on the basis of 2D materials.

keywords: bias illumination stress instability; field-effect transistor; MoS₂; trap state

4-65 *Life Sciences & Biomedicine - Other Topics*

Whole genome sequence of a *Pseudoalteromonas* sp. strain SiA1 isolated from a *Pterocirrus* species in the Antarctic Ocean

Jeon, Kyuwon., Kang, Sia., Lee, Young Jun., **Kim, Dockyu.** and Kim, Eungbin.

Korean Journal of Microbiology. 2022. 58(2): 96-98.

doi: 10.7845/kjm.2022.2022

In this study, whole-genome sequencing analysis was conducted on *Pseudoalteromonas* sp. strain SiA1 isolated from the intestines of the Antarctic

Ocean-dwelling starfish (*Pterocirrus* sp.). Its complete genome sequence consists of two chromosomes, which have 3,355,071 bp and 715,567 bp, respectively. Also, their G + C contents are 40.44% and 39.79%, respectively. A computer-aided analysis detected a total of 3,597 open reading frames, of which at least 98 (~2.7%) are suspected to encode different kinds of proteolytic enzymes.

keywords: Antarctic Ocean; extracellular protease; starfish; symbiotic

4-66 Agriculture; Veterinary Sciences; Zoology

Whole-Genome Survey and Microsatellite Marker Detection of Antarctic Crocodile Icefish, *Chionobathyscus dewitti*

Kim, Jinmu., Lee, Seung-Jae., **Jo, Euna.**, Choi, Eunkyung., Cho, Minjoo., Choi, Soyun., **Kim, Jeong-Hoon.** and Park, Hyun.

Animals. 2022. 12(19).

doi: 10.3390/ani12192598

The crocodile icefish, *Chionobathyscus dewitti*, belonging to the family Channichthyidae, is an endemic species of the Southern Ocean. The study of its biological features and genetics is challenging as the fish inhabits the deep sea around Antarctic waters. The icefish, the sole cryopelagic species, shows unique physiological and genetic features, unlike other teleosts. It lacks hemoglobin and has evolved antifreeze proteins. Here, we report the genome sequencing data of crocodile icefish produced using the Illumina Novaseq 6000 platform. The estimated genome size was 0.88 Gb with a K-value of 19, and the unique sequence, heterozygosity, error, and duplication rates were 57.4%, 0.421%, 0.317%, and 0.738%, respectively. A genome assembly of 880.69 Mb, with an N50 scaffold length of 2401 bp, was conducted. We identified 2,252,265 microsatellite motifs from the genome assembly data, and dinucleotide repeats (1,920,127; 85.25%) had the highest rate. We selected 84 primer pairs from the genome survey assembly and randomly selected 30 primer pairs for validation. As a result, 15 primer pairs were validated as microsatellite markers.

keywords: *Chionobathyscus dewitti*; crocodile icefish; Illumina Novaseq 6000; Jellyfish; GenomeScope; K-value; microsatellite

4-67 Biochemistry & Molecular Biology; Chemistry

Wistin Exerts an Anti-Inflammatory Effect via Nuclear Factor- κ B and p38 Signaling Pathways in Lipopolysaccharide-Stimulated RAW264.7 Cells

An, Jangeun., Ryu, Gyoungah., Shin, Seong-Ah., Kim, Huiji., Ahn, Mi-Jeong., **Lee, Jun Hyuck.** and Lee, Chang Sup.

Molecules. 2022. 27(17).

doi: 10.3390/molecules27175719

Inflammation is an immune response to cellular damage caused by various stimuli (internal or external) and is essential to human health. However, excessive inflammatory responses may be detrimental to the host. Considering that the existing drugs for the treatment of inflammatory diseases have various side effects, such as allergic reactions, stomach ulcers, and cardiovascular problems, there is a need for research on new anti-inflammatory agents with low toxicity and fewer side effects. As 4',6-dimethoxyisoflavone-7-O- β -d-glucopyranoside (wistin) is a phytochemical that belongs to an isoflavonoid family, we investigated whether wistin could potentially serve as a novel anti-inflammatory agent. In this study, we found that wistin significantly reduced the production of nitric oxide and intracellular reactive oxygen species in lipopolysaccharide-stimulated RAW 264.7 cells. Moreover, wistin reduced the mRNA levels of pro-inflammatory enzymes (inducible nitric oxide synthase (iNOS) and cyclooxygenase (COX-2)) and cytokines (interleukin (IL)-1 β and IL-6) and significantly reduced the protein expression of pro-inflammatory enzymes (iNOS and COX-2). Furthermore, wistin reduced the activation of the nuclear factor- κ B and p38 signaling pathways. Together, these results suggest that wistin is a prospective candidate for the development of anti-inflammatory drugs.

keywords: inflammation; phytochemical; wistin

4-68 Biotechnology & Applied Microbiology; Oncology

7 β -22 Dihydroxyhopane, Isolated from the Sub-Antarctic Lichen, Inhibits the Viability and Stemness in Glioma Stem Like Cells

Kim, Hyun-Jin., Suh, Sung-Suk., Park, Jeongwoo., Shin, Min-Ji., **Koo, Man Hyung.** Lee, Suk Jun., Jeon, Young-Jun., Lee, Seongsoo., **Youn, Ui-Joung.** and Kim, Sung-Hak.

OncoTargets and Therapy. 2022. 15: 1375-1383.

doi: 10.2147/OTT.S371042

Background: Glioma stem cells (GSCs) have been reported to contribute to tumor initiation and relapse, therapy resistance, and intratumoral heterogeneity of glioblastoma multiforme. Therefore, inhibiting GSCs presents a critical therapeutic tactic to suppress the aggressiveness of tumors.

Methods: In this study, we examined the effects of 7 β -22 dihydroxyhopane (AP 18), isolated from the sub-Antarctic lichen, *Pseudocyphellaria freycinetii*. The cytotoxic effect of AP 18 and its effects on cell proliferation were assessed by alamarBlue assay and 5-ethynyl-2'-deoxyuridine (EdU) assay. Real-time confluence analysis was performed with a Celloger automatic live cell imaging system. Western Blotting and 3-D optical diffraction tomography (ODT) imaging were performed to determine whether apoptosis was triggered by AP 18. A Limiting dilution assay and qRT-PCR were performed to investigate the impact of AP 18 on GSC stemness. Results: AP 18 significantly reduced GSCs viability and proliferation, inducing programmed cell death identified by Annexin V/PI staining and had effects on morphologic features determined by 3-D ODT. Interestingly, treatment with AP 18 suppressed stemness features.

Conclusion: Taken together, our results suggest that AP 18 might be a potential therapeutic agent to target GSCs.

keywords: Glioblastoma, glioma; *Pseudocyphellaria freycinetii*; hopane triterpenoid

5-1 *Environmental Sciences & Ecology; Physical Geography; Geology*

Ant-ICON-'Integrated Science to Inform Antarctic and Southern Ocean Conservation': a new SCAR Scientific Research Programme

Hughes, Kevin A., Santos, Mercedes., Caccavo, Jilda A., Chignell, Stephen M., Gardiner, Natasha B., Gilbert, Neil., Howkins, Adrian., Van Vuuren, Bettine Jansen., Lee, Jasmine R., Liggett, Daniela., Lowther, Andrew., Lynch, Heather., Quesada, Antonio., **Shin, Hyoung Chul.** and 2 others.

Antarctic Science. 2022. 34(6): 446-455.

doi: 10.1017/s0954102022000402

Antarctic and Southern Ocean environments are facing increasing pressure from multiple threats. The Antarctic Treaty System regularly looks to the Scientific Committee on Antarctic Research (SCAR) for the provision of independent and objective advice based on the best available science to support decision-making, policy development and effective environmental management. The recently approved SCAR Scientific Research Programme Ant-ICON - 'Integrated Science to Inform Antarctic and Southern Ocean Conservation' - facilitates and coordinates high-quality transdisciplinary research to inform the conservation and management of Antarctica, the Southern Ocean and the sub-Antarctic in the context of current and future impacts. The work of Ant-ICON focuses on three research themes examining 1) the current state and future projections of Antarctic systems, species and functions, 2) human impacts and sustainability and 3) socio-ecological approaches to Antarctic and Southern Ocean conservation, and one synthesis theme that seeks to facilitate the provision of timely scientific advice to support effective Antarctic conservation. Research outputs will address the most pressing environmental challenges facing Antarctica and offer high-quality science to policy and advisory bodies including the Antarctic Treaty Consultative Meeting, the Committee for Environmental Protection and the Scientific Committee of the Commission for the Conservation of Antarctic Marine Living Resources.

keywords: Antarctic Treaty System; best available science; capacity building; environmental protection; human impact; science-policy communication

5-2 Area Studies

Changes and Implications of the Russian-Arctic Zone by Period

Seo, Hyun Kyo.

Journal of European Union Studies. 2022. 62: 37-66.

doi: 10.18109/jeus.2022.62.37

Russia, which has the largest territory and the most resources in the Arctic of the Arctic Countries, from the era of the Soviet regime(the former Soviet Union) has designated and managed the Arctic Zone of the Russia. The Arctic territory designated in this way differed by period, and such differences reflect the government's Arctic policy philosophy at that time. In this study, the changes in the Arctic Territory Designation Region from the Soviet regime, around 100 years ago, to the present Russian Putin government, were examined by time period, and the differences and characteristics of each were analyzed. First, in the Arctic Territory designated during the Soviet era in 1926, the territorial definition of land or islands in the Arctic Ocean north of the Russian mainland was established, and the concept of the Arctic Zone at the end of the former Soviet Union was established with the adoption of the United Nations Convention on the Law of the Sea(UNCLOS) in 1982. The Current Russian government has designated the Arctic Zone, which combines the concepts of territory and administrative division based on territorial security and economic revitalization, by time through laws, presidential decrees, and policy announcements etc. Designated Zone has been gradually subdivided into cities under states or autonomous districts and expanded. In addition, the government's efforts to secure the sustainability of the Russian Arctic region through the influx of a settled population may have been reflected in the designation of the Arctic region, while seeking to vitalize the Russian Arctic economy through the supportive policy like business investment attraction and administrative support etc.

keywords: Russia; Arctic Territories; Arctic Zone; Arctic policy; Arctic Geography

5-3

Design of an Absorptive High-Power PIN Diode Switch for an Ultra-Wideband Radar

Elluru, Deepak N., Awasthi, Abhishek K., Gogineni, S. Prasad., Taylor, Drew, Shahabi, Ali., Lemmon, Andrew N., **Chung, Changhyun.** and **Lee, Joohan.**

IEEE Journal of Microwaves. 2022. 2(2): 286-296.

doi: 10.1109/JMW.2021.3138889

This paper details the development of a low-loss, PIN diode single-pole double-throw (SPDT) absorptive switch for an ultra-wideband radar. The fabricated switch operates with a peak power of 200 watts at a 10% duty cycle. It has an insertion loss of less than 0.8 dB, a return loss greater than 19 dB, and isolates the transmitter and receiver beyond 37 dB over the frequency band (170 MHz-470 MHz) for sensitive radar measurements. An external RF limiter and a low-power CMOS switch at the receiving end are used to reduce video leakage from the PIN diode switch and enhance the isolation up to 80 dB. A fast-switching MOSFET-based PIN diode driver circuit is designed with a dead-time control circuit to minimize the cross-conduction currents for the PIN diode switch. The rise and fall times for the PIN diode switch are less than 200 ns. The switch-driver includes integrated low-noise power supplies that generate -50 V, 15 V, and 5 V from a common rail 50 V input source.

keywords: Driver; MOSFET; PIN diodes; radar; SPDT; switch; T/R switch

5-4 Science & Technology - Other Topics; Materials Science

Icephobic Coating through a Self-Formed Superhydrophobic Surface Using a Polymer and Microsized Particles

Moon, Chan Hui., Yasmeen, Sumaira., Park, Kiho., Gaiji, Houda., **Chung, Changhyun.** and 4 others.

Acs Applied Materials & Interfaces. 2022. 14(2): 3334-3343.

doi: 10.1021/acsami.1c22404

Icephobic coatings have been extensively studied for decades to overcome the potential damage associated with ice formation in various devices that are operated under harsh weather conditions. Superhydrophobic surface coatings have been applied for icephobic coating applications owing to their low surface energy. In this study, an icephobic coating of a self-formed

superhydrophobic surface using polydimethylsiloxane (PDMS) and SiO₂ powder was investigated. The effect of superhydrophobicity on icephobicity was determined by varying the experimental parameters. Polyvinylidene fluoride (PVDF) was added to the PDMS solution to improve the mechanical properties of the icephobic layer. The PDMS-PVDF solution also showed a self-formation behavior into a superhydrophobic surface. In addition, the icephobicity and mechanical properties of the PDMS-PVDF mixture coating improved because of the multilevel nanostructure formed by physical and chemical interactions between the mixture and SiO₂ powder. We believe that the proposed approach will be a suitable candidate for various practical applications of icephobicity and a model system to understand the correlation between superhydrophobicity and icephobicity.

keywords: superhydrophobic; icephobic; polydimethylsiloxane; SiO₂ powder; polyvinylidene fluoride; ice adhesion; roughness

to the Newton-Raphson power-flow calculation and the sequence network decomposition methods. The proposed normalized cost function includes not only voltage variations determined by the power-flow method, installation costs, and power losses but also fault current determined by the sequence method. As a result, the objective function of the new design, adding the normalized fault current cost, enables the solution set to be more optimal than the previous solution set.

keywords: Distributed generation; Fault current; Objective function; Optimal allocation; Particle swarm optimization

5-5 Engineering

A New Design of the Objective Function for the Optimal Allocation of Distributed Generation with Short-Circuit Currents

Son, Seung-Wan., Lee, Dong-Hyeon., Kim, Insu., **Jung, Chang-Hyeon., Kim, Hyoungkwon., Yoon, Dong-Jin. and Lee, Joohan.**

Journal of Electrical Engineering & Technology. 2022. 17(3): 1487-1497.

doi: 10.1007/s42835-021-00978-0

Renewable energy sources reduce irresponsible carbon emissions and have the advantage of being located close to the load as a distributed generation (DG). Thus, various studies have examined the optimal placement and capacity of DG to maximize their effect on power grids. However, there was no paper that considered the normalized cost including the fault current in the process of the optimal allocation of DG. The reason that the normalized fault current cost should be included in objective function is that the more DG is connected to the network, the higher fault current will flow. Thus, this paper presents a method of optimizing the DG placement and capacity from a novel perspective using normalized costs that minimize the fault current. For this purpose, this study incorporates the particle swarm optimization method

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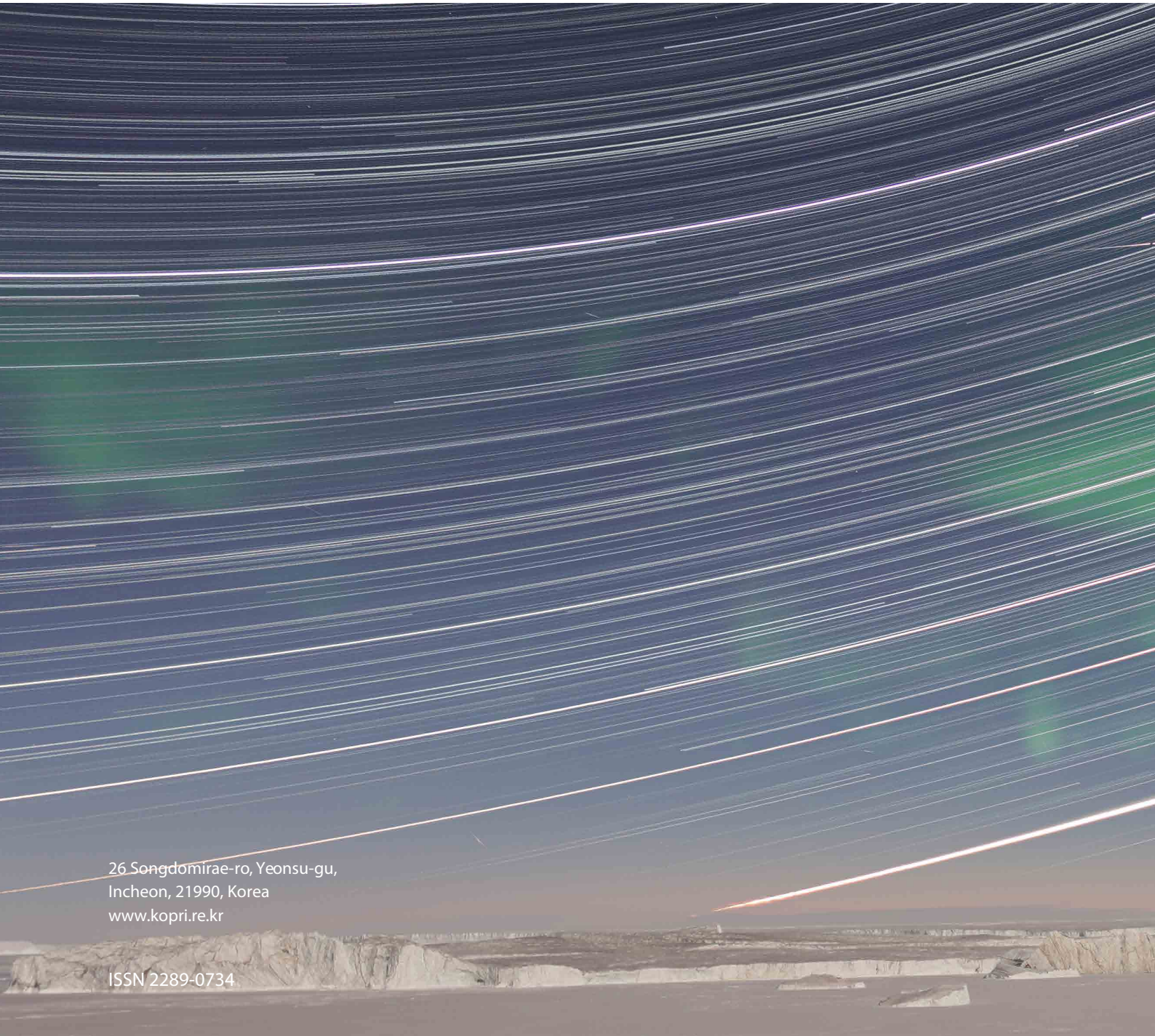
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