



KOPRI ABSTRACTS

국지연구소 2025년 논문 초록집

2025 _ Volume 17



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Summary of 2025 Research Paper Achievements

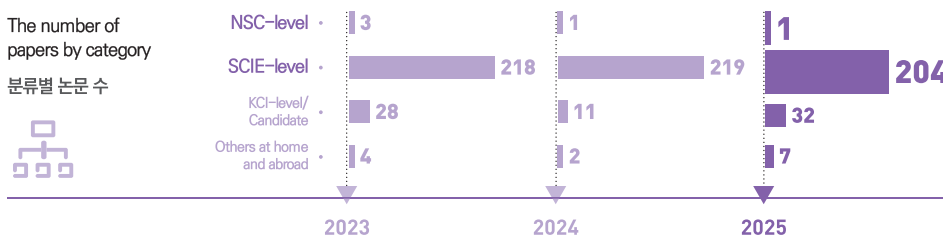
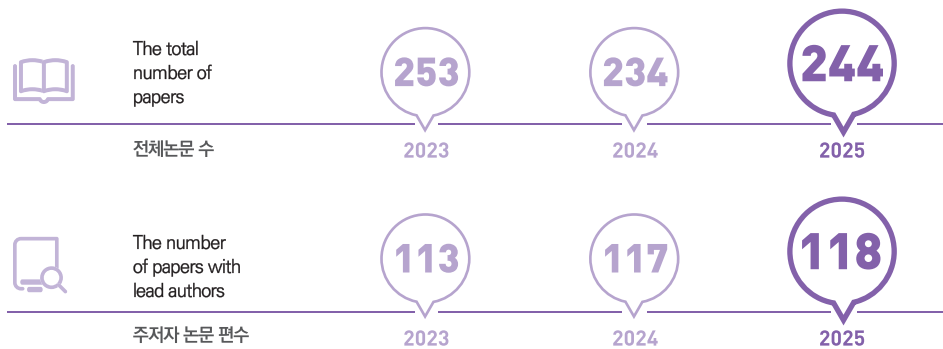
2025년 연구논문 성과 요약

01. Research papers in recent 3 years

최근 3년간
연구논문 성과

최근 3년간 KOPRI의 연구논문 성과와 국내외 공동연구, 연구 주제 분야 및 주요 저널의 동향을 살펴보았다. KOPRI의 SCIE급 논문을 Clarivate Analytics의 Web of Science 데이터와 지표를 기반으로 분석하였다.

We examined KOPRI's research performance over the past three years, including research paper publications, domestic and international collaborative research, research subject fields, and trends in major journals. KOPRI's SCIE-level papers were analyzed using data and indicators from Web of Science, a database maintained by Clarivate Analytics.



02. Collaborative research results at home and abroad

국내외 공동 연구성과

2025년 Web of Science에 색인된 SCIE/NSC 논문 205편의 분석 결과, 극지연구소는 36개국, 516개 기관과 공동연구를 수행한 것으로 나타났다.

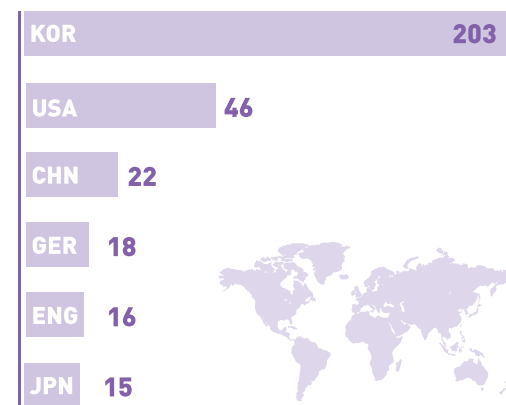
Based on an analysis of 205 SCIE-indexed papers (including NSC papers) indexed in WoS in 2025, KOPRI collaborated with 516 institutions across 36 countries.



• Top 5 countries and number of research papers

공동연구 수행 국가 TOP 5 및 논문 수

Country	Number of papers	% of total papers
Republic of Korea 대한민국	203	99.0%
USA 미국	46	22.4%
China 중국	22	10.7%
Germany 독일	18	8.7%
England 영국	16	7.8%
Japan 일본	15	7.3%



03. Subject fields of research

연구 주제 분야

2025 KOPRI Abstracts 연구 주제는 기후과학, 생명과학, 지구시스템, 해양과학, 정책&기술 분야로 분류하였다. 기후과학은 대기, 고층대기, 빙하, 고기후, 고환경, 원격탐사 등을 포함하며, 생명과학은 유전학·유전체학, 생리·생화학, 생물다양성·생태·진화, 생물공학 등을 포함한다. 지구과학은 지질, 지구물리, 수중음향 등을 포함한다. 해양과학은 해양학(물리, 화학, 생물학, 지질학)뿐만 아니라 해양환경에 따른 생태학 및 기술개발 등의 주제를 포함하였다.



• Top 5 Domestic Collaborative Institutions and Number of Co-authored Papers

공동연구 수행기관(국내) TOP 5 및 논문 수

Institution	Number of papers	Share of total papers
Korea Polar Research Institute (KOPRI) 극지연구소	196	95.6%
University of Science and Technology (UST) 과학기술연합대학원대학교	48	23.3%
Seoul National University (SNU) 서울대학교	23	11.2%
Yonsei University 연세대학교	23	11.2%
Korea Institute of Ocean Science and Technology (KIOST) 한국해양과학기술원	15	7.3%
Korea University 고려대학교	14	6.8%

• Top 5 International Collaborative Institutions and Number of Research Papers

공동연구 수행기관(국외) TOP 5 및 논문 수

Institution	Number of papers	Share of total papers
Helmholtz Association	11	5.2%
ALFRED WEGENER INSTITUTE HELMHOLTZ CENTRE FOR POLAR MARINE RESEARCH (AWI)	10	4.8%
Ministry of Earth Sciences (MoES), India	9	4.3%
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)	8	3.9%
CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE (CNRS)	6	2.9%

• Subject fields of research in 2025 KOPRI Abstracts

2025 KOPRI Abstracts의 연구주제 분야

Research topics in 2025 KOPRI Abstracts are categorized into Climate Sciences, Life Sciences, Geosciences, Marine Sciences, and Policy&Technology. **Climate Sciences** cover paleoclimate, atmospheric 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 related to marine environments.

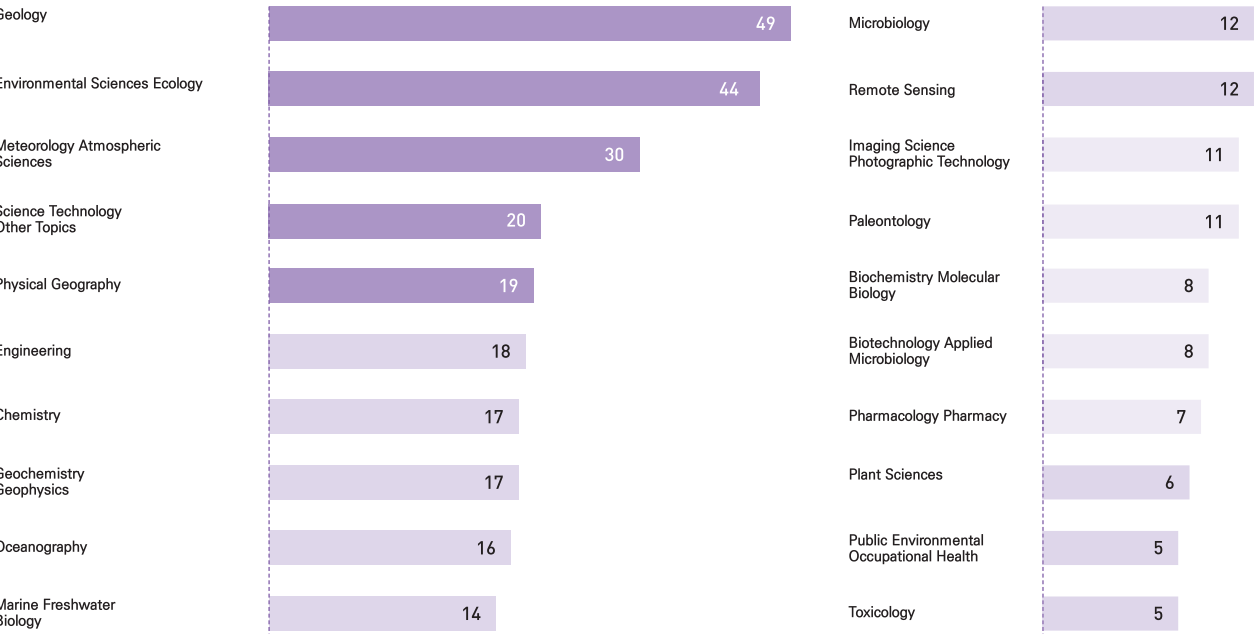
04. Web of Science Categories

WoS 연구 분야



Top 20 Subject fields of research

Wos 연구 분야 Top 20



*Source: Web of Science, Clarivate Analytics

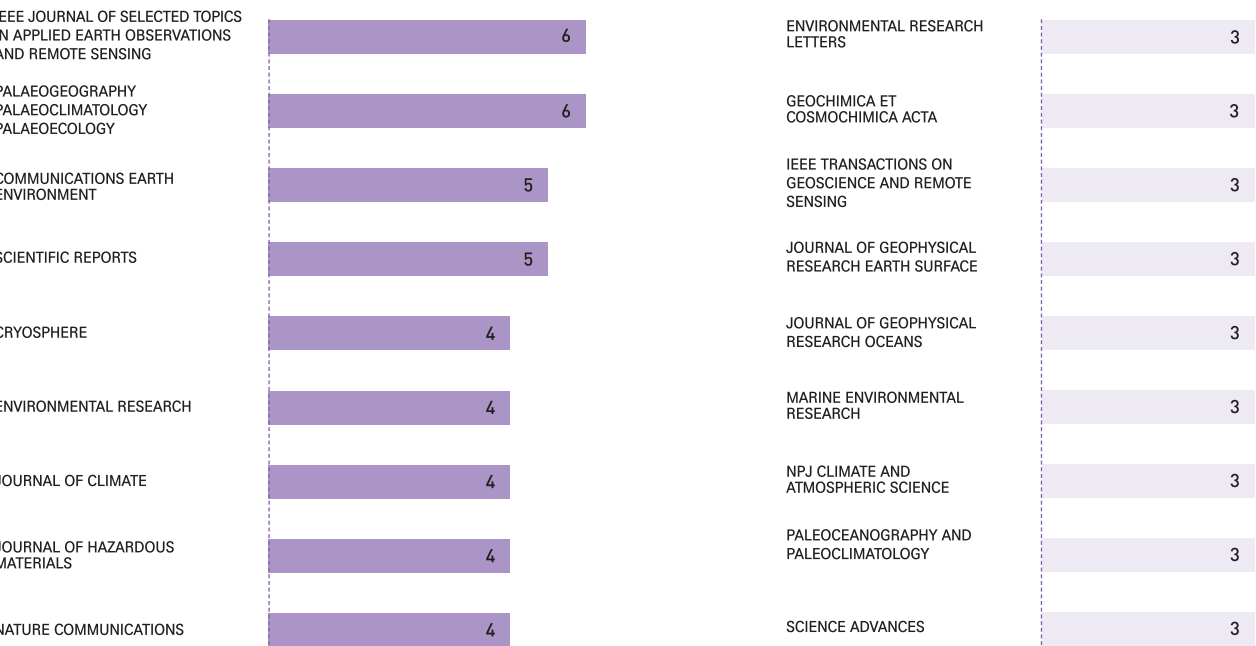
05. Major journals registered

주요 등재 저널



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

3편 이상 등재된 저널과 논문 수



*Source: Web of Science, Clarivate Analytics

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NOTICE

Web of Science Subject

If no Web of Science Subject is listed in this bibliography, the article is published in a journal that is not assigned to a Web of Science Subject Category.

Reference

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

Abstract

Keywords

1-30 Oceanography

Ice Shelf Water-Influenced Fast Ice and Sub-Ice Platelet Layer Near the Campbell Ice Tongue, Terra Nova Bay

Brett, Gemma Marie., Gardiner, Natasha., Langhorne, Pat., Rack, Wolfgang., Haas, Christian., Irvin, Anne. **and Kim, Sanghee.**

Journal of Geophysical Research-Oceans. 2025. 130(11).

doi: 10.1029/2024jc021342.

Here, we present the first dedicated in situ measurements of the thickness distributions of fast ice and the sub-ice platelet layer, formed by supercooled Ice Shelf Water in north Terra Nova Bay, Antarctica. With the objective of inferring source regions and circulation of Ice Shelf Water, we measured fast ice and sub-ice platelet layer thickness distributions near the Campbell Ice Tongue in late spring of 2021, using drill hole surveys and high-resolution ground-based electromagnetic induction soundings. We observed thicker fast ice and sub-ice platelet layer near the ice tongue with very thick and narrow sub-ice platelet layer maxima indicating highly channeled outflow of supercooled Ice Shelf Water from beneath the ice tongue directed by ice mélange, subglacial formations, and grounded regions. We conclude that a significant volume of supercooled Ice Shelf Water is locally sourced from the Campbell Ice Tongue through basal melting and affirm that the icescape in north Terra Nova Bay results from a complex interplay of glacial morphology, polynya forcing, and ocean circulation.

keywords:

land-fast sea ice; sub-ice platelet layer; ice tongue; ice-ocean interactions; Antarctic coastal zone; electromagnetic induction

Part 01.

Climate Sciences

1-1

Geochemistry & Geophysics; Engineering, Electrical & Electronic; Remote Sensing; Imaging Science & Photographic Technology

Advanced Algorithm for Continuous Melt Onset Detection on Arctic Sea Ice

Kim, Jong–Min., Kim, Hyun–Cheol., Park, Jeong–Won., Park, Jinku. and 2 others.
IEEE Transactions on Geoscience and Remote Sensing. 2025. 63.
doi: 10.1109/tgrs.2025.3560261.

Expansion of the Arctic melting season with an earlier melt onset date (MOD) is a well-known indicator of Arctic warming. Since 1979, the pan-Arctic MOD distributions usually have been estimated using passive satellite microwave radiometer observations. However, there is a poor agreement in MOD between previous MOD detection algorithms based on passive microwave measurements, raising doubts regarding the accuracy of their MOD products. Thus, this study developed a new MOD algorithm, namely TBmax algorithm, to improve the estimation accuracy of continuous melt onset. The TB(max) algorithm utilizes the microwave radiation characteristics of sea ice, and the daily brightness temperature time series shows their maximum brightness temperature on MOD. By using AMSR2 brightness temperature data, the pan-Arctic MOD distributions estimated from 2013 to 2021 using the TB(max) algorithm successfully reproduced a feature of sea ice melting that mainly during May or June over the Arctic, including the late melting tendency of ice at high latitudes and multiyear ice (MYI). Validation with independent dataset (ice mass balance (IMB) buoy data) suggested that the TBmax MODs showed superior performance compared to other previous algorithms (biases of 0.1 days versus –2.7 and 13.9 days). As MOD can provide information about surface emissivity and the energy budget of the sea ice, the improved MOD may contribute to

a more precise analysis of Arctic environment change and enhanced estimation of sea ice parameters.

keywords:

Sea ice; Microwave radiometry; Arctic; Ice; Snow; Microwave integrated circuits; Microwave FET integrated circuits; Ocean temperature; Electromagnetic heating; Time series analysis; Arctic melting season; melt onset date (MOD); passive microwave; sea ice melt

1-2

Engineering, Chemical; Engineering, Mechanical; Environmental Sciences; Meteorology & Atmospheric Sciences

Aerosol hygroscopicity influenced by seasonal chemical composition variations in the Arctic region

Kang, Hyojin., Jung, Chang Hoon., Lee, Bang Yong., Krejci, Radovan., Heslin-Rees, Dominic., Aas, Wenche. and Yoon, Young Jun.
Journal of Aerosol Science. 2025. 186.
doi: 10.1016/j.jaerosci.2025.106551.

In this study, we quantified aerosol hygroscopicity parameter using aerosol microphysical observation data (κ_{phy}), analyzing monthly and seasonal trends in κ_{phy} by correlating it with aerosol chemical composition over 6 years from April 2007 to March 2013 at the Zeppelin Observatory in Svalbard, Arctic region. The monthly mean κ_{phy} value exhibited distinct seasonal variations, remaining high from winter to spring, reaching its minimum in summer, followed by an increase in fall, and maintaining elevated levels in winter. To verify the reliability of κ_{phy} , we employed the hygroscopicity parameter calculated from chemical composition data (κ_{chem}). The chemical composition and PM_{2.5} mass concentration required to calculate κ_{chem} was obtained through Modern-Era Retrospective Analysis for Research and Applications, version 2 (MERRA-2) reanalysis data and the calculation of κ_{chem} assumed that Arctic aerosols comprise only five species: black carbon (BC), organic matter (OM), ammonium sulfate (AS), sea salt aerosol less than a diameter of 2.5 μm (SSA_{2.5}), and dust aerosol less than a diameter of 2.5 μm (Dust_{2.5}). The κ_{chem} had no distinct correlation but had a similar seasonal trend compared to

κ_{phy} . The κ_{chem} value followed a trend of SSA_{2.5} and was much higher by a factor of 1.6 ± 0.3 than κ_{phy} on average, due to a large proportion of SSA_{2.5} mass concentration in MERRA-2 reanalysis data. This may be due to the overestimation of sea salt aerosols in MERRA-2 reanalysis. The relationship between monthly mean κ_{phy} and the chemical composition used to calculate κ_{chem} was also analyzed. The elevated κ_{phy} from October to February resulted from the dominant influence of SSA_{2.5}, while the maximum κ_{phy} in March was concurrently influenced by increasing AS and Dust_{2.5} associated with long-range transport from mid-latitude regions during Arctic haze periods and by SSA mass concentration obtained from in-situ sampling, which remained high from the preceding winter. The relatively low κ_{phy} from April to September can be attributed to low SSA_{2.5} and the dominance of organic compounds in the Arctic summer. Either natural sources such as those of marine and terrestrial biogenic origin or long-range-transported aerosols may contribute to the increase in organic aerosols in summer, potentially influencing the reduction in κ_{phy} of atmospheric aerosols. To our knowledge, this is the first study to analyze the monthly and seasonal variation of aerosol hygroscopicity calculated using long-term microphysical data, and this result provides evidence that changes in monthly and seasonal hygroscopicity variation occur depending on chemical composition.

keywords:

Aerosol hygroscopicity parameter; Arctic region; Microphysical data; Sea salt aerosol; Aerosol-cloud interaction; Community atmospheric model

1-3

Geosciences, Multidisciplinary; Meteorology & Atmospheric Sciences

An Arctic sea ice concentration data record on a 6.25 km polar stereographic grid from 3 years of Landsat-8 imagery

Jung, Hee-Sung., Lee, Sang-Moo., Kim, Joo-Hong. and Lee, Kyungsoo.
Earth System Science Data. 2025. 17(1): 233–258.
doi: 10.5194/essd-17-233-2025.

The decline in Arctic sea ice in the global warming era has received much attention as a contributing factor to the changes

in the weather and climate in the Arctic and beyond. The coverage of Arctic sea ice (i.e. sea ice concentration (SIC)) has been monitored since 1972 using satellite passive microwave (PMW) measurements because of their extensive coverage and all-weather capability. However, the fundamental basis of algorithms for estimating SIC has not improved much since the early days due to the lack of reference SIC data, leading to discrepancies between existing PMW SIC algorithms. To overcome this issue, this study aims to construct data records of reference SIC over Arctic sea ice using 30 m resolution imagery from the Operational Land Imager (OLI) on board Landsat-8. In order to collect relatively bright and clear scenes, thresholds of solar elevation >15 degrees and cloud cover <10 % were applied in this study. Clouds in each Landsat-8 scene were masked using the cloud-masking array provided in Landsat data. Due to the poor accuracy of the cloud-masking array over ice-covered surface types, an additional step of visually inspecting the state of the cloud mask using the true-colour image was designated in this study. Each Landsat-8 scene was sorted into four categories depending on the state of the cloud mask. The normalized difference snow index and OLI band-5 reflectivity were used to differentiate between ice and open water within each selected Landsat-8 pixel. The classified data were projected onto a 6.25 km polar stereographic grid, and SIC for each grid cell was obtained by counting ice-classified pixels within the grid. SIC was only computed for grid cells where more than 99 % of their area was covered with Landsat-8 pixels to limit the uncertainty in SIC arising from grids that are not fully concentrated with Landsat-8 pixels. Uncertainty in the produced SIC was 1 %–4 %, inferred using the Gaussian error propagation method. Out of 15 286 collected Landsat-8 images, 14 297 images were translated into SIC maps, and a total of 2 934 399 Landsat-8 SIC grid cells were generated. Evaluation of Landsat-8 SIC with SIC from ice charts revealed a good linear relationship (correlation coefficient of 0.96) between the two products, as well as a mean negative bias which fell within the uncertainty range of Landsat-8 SIC. SIC based on Landsat-8 can be used as reference SIC to evaluate existing SIC products, and, thus, one can improve SIC products, as well as use the improved SIC for other applications such as data assimilation and retrieval studies. The vast amount of Landsat-8 SIC generated in this study may also be used to train deep-learning models for the estimation of Arctic SIC coverage. The Landsat-8 SIC dataset can be publicly accessed at <https://doi.org/10.5281/zenodo.10973297> (Jung et al., 2024), and the Python codes for the production and evaluation of the Landsat-8 SIC dataset are accessible at <https://doi.org/10.5281/zenodo.12754602> (Jung, 2024).

1-4

Geochemistry & Geophysics; Engineering, Electrical & Electronic; Remote Sensing; Imaging Science & Photographic Technology

Application of the Satellite-Based Spectral Relationship to the Vertical Localization for the Microwave Humidity Sounder in the Ensemble Kalman Filter

Noh, Young-Chan., Chung, Eui-Seok., Choi, Yonghan., Song, Hyo-Jong., Raeder, Kevin. and Kim, Joo-Hong.
IEEE Transactions on Geoscience and Remote Sensing. 2025. 63.
doi: 10.1109/tgrs.2025.3575606.

Localization is an essential technique to mitigate the sampling error in the ensemble Kalman filter (EnKF). In order to effectively use the localization function within the EnKF, the specific location information of observations being assimilated is required to measure the distance between the model state variables and the observations. Since the satellite-observed radiance represents integrated quantities across the entire vertical profile of an atmospheric column, it is, however, a challenging issue to accurately assign the vertical location, especially for the satellite radiances sensitive to the variable atmospheric constituents (e.g., water vapor). In this study, we propose an efficient method for assigning the vertical location for observations of microwave humidity sounders (MHSs) onboard low-earth-orbiting (LEO) satellites, using discrete spectral characteristics between the 60 GHz oxygen and 183 GHz water vapor absorption bands. As the radiance differences between the channels are solely used as the predictors for estimating the vertical location in a multivariate regression framework, there is no need to conduct radiative transfer simulations that require additional computation costs. The estimated vertical locations are employed for the vertical localization function within the Data Assimilation (DA) Research Testbed (DART) implementation of ensemble filtering. The verification results show that applying vertical localization to observations from MHSs significantly improves the water vapor analysis derived by the DART system, particularly in the lower troposphere.

keywords:
Atmospheric modeling; Sensitivity; Location awareness; Channel estimation; Satellites; Atmospheric measurements; Humidity; Predictive models; Microwave theory and

techniques; Jacobian matrices; Ensemble Kalman filter (EnKF); microwave humidity sounder (MHS); vertical localization

1-5

Environmental Sciences; Geosciences, Multidisciplinary; Meteorology & Atmospheric Sciences

Arctic fjord ecosystem adaptation to cryosphere meltdown over the past 14,000 years

Knies, Jochen., Ahn, Youngkyu., Ebner, Berenice., Smik, Lukas., Jang, Kwangchul., Nam, Seung-II. and 2 others.
Communications Earth & Environment. 2025. 6(1).
doi: 10.1038/s43247-025-02251-y.

The Arctic cryosphere is the epicentre of acute global change impact, with abrupt warming and amplification driving rapid sea ice decline and irreversible glacial ice loss. A key challenge is understanding how the cryosphere meltdown will impact Arctic marine carbon cycles and ecosystems. Here, we use organic geochemical biomarkers to trace the contribution of different planktonic groups to organic carbon in Arctic fjord sediments (Kongsfjorden, Svalbard) during past warmer and colder (than present) climate states. We show that phytoplankton community structures changed abruptly with variable sea ice cover and glacial ice loss. Our results imply that future deglaciation of Svalbard fjords will likely increase primary productivity in a “blue” (summer ice-free) scenario; however, the potential for fjords to serve as hotspots of marine organic carbon burial will likely be constrained due to warmer, stratified waters and reduced meltwater-induced supply of critical nutrients.

1-6

Astronomy & Astrophysics; Geochemistry & Geophysics; Meteorology & Atmospheric Sciences

Assessment of Current Capabilities in Modeling the Ionospheric Climatology for Space Weather Applications: foF2 and hmF2-II

Jee, Geonhwa. and 13 others.
Space Weather—the International Journal of Research and Applications. 2025. 23(6).
doi: 10.1029/2024sw004166.

We expand the assessment study of modeling capabilities in the prediction of foF2 and hmF2 for the ionospheric climatology (Tsagouri et al., 2018, <https://doi.org/10.1029/2018sw002035>) by using updated empirical (IRI and MIT Empirical model) and physics-based models (CTIpe, WACCM-X, and TIE-GCM) as well as the additional observations in the southern hemisphere. Monthly medians of foF2 and hmF2 are considered to evaluate the model performance for the entire year of 2012. For quantitative evaluation, we employ several metrics including the correlation coefficient (R), coefficient of determination (R^2), root-mean square error (RMSE), mean error (ME), and mean relative error (MRE). The linear regression analysis shows that the empirical models perform much better than physics-based models for foF2 but to a lesser degree for hmF2. There are negligible hemispheric differences in the predictions from empirical models. All the physics-based models show relatively good correlations with the observations for foF2 in the northern hemisphere compared to the southern hemisphere, but the hemispheric differences are small for hmF2. The results of the study indicate that recent versions of empirical models tend to perform better than old versions of the models, but this is not always true for physics-based models.

keywords:
ionospheric model; ionospheric climatology; space weather

1-7

Geosciences, Multidisciplinary

Assessment of trace elements distribution and sources from snowpits in the Lambert Glacier region, coastal East Antarctica

Nyamgerel, Yalalt., Do Hur, Soon. and 4 others.
Geoscience Frontiers. 2025. 16(3).
doi: 10.1016/j.gsf.2025.102045.

The measurement of trace elements in Antarctic snow is crucial for understanding historical atmospheric geochemical changes and circulation patterns. However, studies on their spatial distributions remain limited, particularly those evaluating multiple metals across several snowpits, making interpretation challenging. This study investigates the distributions and sources of trace elements—including Cd, Ba, Pb, U, Bi, V, Mn, Fe, Cu, Zn, and As—across four snowpits in the Lambert

Glacier Basin, East Antarctica. The trace elements exhibit site-, element-, and season-dependent variations, with higher concentrations observed at inland sites. In contrast, $\delta^{18}\text{O}$ and ion concentrations decrease with increasing distance from the coast and elevation, underscoring the influence of marine emissions. Crustal sources primarily contributed to Ba, U, V, Mn, and Fe, while non-crustal sources predominantly contributed to Cd, Bi, Zn, Pb, Cu, and As. Positive matrix factorization (PMF) analysis indicates that trace element concentrations in Pits 2 and 3 are influenced by both crustal and non-crustal sources, while Pit 4 reflects a mixed-source influence. Pit 1 (coastal site) also indicates the mixed sources with influence of a highly dynamic marine climate and environment. The PMF results reveal similarities in emission sources and atmospheric transport patterns across the snowpits, facilitating a more comprehensive interpretation of longer ice core records. Overall, this study provides valuable insights into trace element distributions and enhances our understanding of past environmental and climatic conditions.

keywords:
Trace elements; Spatial variation; Antarctica; Lambert Glacier Basin; Positive matrix factorization

1-8

Engineering, Environmental; Environmental Sciences; Water Resources

Bromide oxidation by bromate in a frozen solution and reactive bromine species production

Ahn, Yong-Yoon., Nguyen, Quoc Anh., Spolaor, Andrea., Frassati, Stefano., Barbaro, Elena., Cozzi, Giulio., Turetta, Clara., Oh, Hoon., Lee, Jaesang. and Kim, Kitae.
Water Research. 2025. 285.
doi: 10.1016/j.watres.2025.124127.

A sudden increase in tropospheric reactive bromine species (such as BrO radical) concentration has been observed in the Arctic springtime (bromine explosion). The reactive bromine radicals originate from the Br₂ oxidation; however, the role of ice chemistry in bromine activation, especially freezing-induced Br[−] oxidation for Br₂ production, is not significantly considered yet. Notably, the freezing phenomenon is prevalent in polar region. In this study, we demonstrate that the Br[−] containing

water freezing can provide a potential Br[−] oxidation pathway. The oxidation of Br[−] by BrO₃[−] was negligible under aqueous conditions, while it was highly accelerated (time scale of several years to minute) by freezing the solution. We proposed that the accelerated chemical reaction was due to the freezing concentration effect. The chemical transformation mechanism was suggested. The chemical transformation of Br[−] was considered using the UV-visible absorbance spectrometer and the high-resolution mass spectroscopy (HRMS) measurement. The total Br content was measured using inductive coupled plasma mass spectroscopy (ICP-MS) and the dissolved Br species was monitored using ion chromatography. The spatial distribution of in-situ generated hypobromous acid in ice was analyzed using the Raman microscopy. The Br[−] oxidation is increased as the decrease of initial pH and increase of reactant dose, but the influence of freezing temperature was not significant. This study provides experimental evidence for the freezing-induced bromide activation in the ice.

keywords:
Ice chemistry; Bromine explosion; Bromide; Hypobromite; Freeze concentration

1-9

Geography, Physical; Geosciences, Multidisciplinary; Paleontology

Changes in iceberg discharge and bottom current activity during the last Glacial to Holocene along the Ross Sea continental margin, Antarctica

Cui, Chao., Xiao, Xiaotong., Liu, Yanguang., Stein, Ruediger., **Nam, Seung-II.** and 5 others.
Palaeogeography Palaeoclimatology Palaeoecology. 2025. 680.
doi: 10.1016/j.palaeo.2025.113353.

Glaciomarine sediments along the continental margins record dynamic depositional processes modulated by ice-ocean interactions. To better understand the changes in iceberg discharge and bottom current activity since the late Last Glacial (Marine Isotope Stage 2 – MIS 2), we investigated glaciomarine sediment cores from the Ross Sea continental margin. Three sediment cores (IT17RS-BC008, IT17RS-BC010, and IT17RS-BC006) were analyzed using multiple proxies, including iceberg-rafted debris (IBRD), sortable silt (SS), grain-size end-

member analysis (EMA), total organic carbon (TOC), $\delta^{13}\text{C}_{\text{org}}$, and biogenic opal. Notably, this study is the first application of SS and EMA techniques to sediment cores from the Ross Sea, and provides new insights into bottom current variability. We identify four phases in the MIS 2 to Holocene depositional evolution: (1) the early MIS 2 (> 21.5 ka) characterized by strong bottom currents and reworked sediments transported by buoyant meltwater plumes, with minimal iceberg input; (2) the final late glacial (21.5 to about 19 ka), marked by a weakening of bottom currents; (3) the deglacial to mid-Holocene period (19 to 7.5 ka), showing increased iceberg calving and strengthened bottom currents; and (4) the mid-to-late Holocene (7.5 to 2 ka), featuring persistently high iceberg and bottom current activity, probably related to a re-advance of the West Antarctic Ice Sheet. A pronounced tipping point around 19 ka suggests that enhanced basal melting may have triggered the destabilization of the ice sheet and a reorganization of abyssal circulation. This study presents new sedimentological evidence and methodological approaches for reconstructing the coupled dynamics of iceberg-ocean circulation along the Antarctic continental margin.

keywords:
Glaciomarine sediments; Grain-size end-member analysis; Sortable silt; Iceberg-rafted debris; Antarctic continental margin; The late last Glacial-Holocene

1-10

Oceanography

Changes in Sedimentary Organic Carbon Compositions in the Mackenzie Trough Over Recent Centuries: Insights Into Permafrost Thawing in the Canadian Arctic

Kim, Dahae., Kim, Jung-Hyun., Joe, Young Jin., Ahn, Youngkyu., Tesi, Tommaso., Lohmann, Gerrit., **Jeong, Sujeong.** and **Nam, Seung-II.**
Journal of Geophysical Research-Oceans. 2025. 130(7).
doi: 10.1029/2025jc022652.

This study analyzed three sediment cores (ARA08C/02-2BC, ARA08C/03-2BC, and ARA04C-40MUC) from the Mackenzie Trough in the Beaufort Sea, collected in 2013 and 2017. Using bulk sediment properties (carbon and nitrogen contents, stable carbon isotopes, and radiocarbon isotopes) and terrestrial

biomarkers (lignin phenols), we examined the impacts of permafrost thaw on sedimentary organic carbon (OC) in the Canadian Beaufort Sea. Our objective was to investigate whether changes in OC sources reflect the environmental changes documented in the region over the past few decades. At the core site of ARA08C/03-2BC, we observed an increase in soil-derived OC accumulation rates (ARs) since the early 20th century, with a noticeable rise over the past few decades, while petrogenic OC ARs showed a slight decline. Grain size end-member (EM) modeling identified three primary EM groups, revealing a general increase in the proportion of coarse grains (sum of EM2 + EM3 end-members) since the early 1900s, with a marked acceleration in recent decades. These trends align with regional surface temperature increases over the past few decades, suggesting that permafrost thaw has increasingly affected sedimentary OC dynamics in the Canadian Beaufort Sea. Given climate models that predict accelerated warming in the Mackenzie Basin, our findings highlight the critical need for precise quantification of OC fluxes to improve projections of regional carbon budgets and climate dynamics in the Arctic.

1-11

Classification of Ionograms Obtained from Vertical Incidence Pulsed Ionospheric Radar (VIPIR)/Dynasonde Ionospheric Radar at Jang Bogo Station, Antarctica

Back, Junho., **Geonhwa, Jee., Kwon, Hyuck-Jin., Kim, Khan-Hyuk., Lee, Changsup., Ham, Young-Bae.** and Zabotin, Nikolay.
Journal of Astronomy and Space Sciences. 2025. 42(2): 39-46.
doi: 10.5140/JASS.2025.42.2.39

The electron density profiles produced from the ionospheric sounding system are traditionally estimated by the inversion procedure based on the image analysis of the observed ionograms. Jang Bogo Vertical Incidence Pulsed Ionospheric Radar (VIPIR) with Dynasonde (hereafter, JVD), however, uses the three-dimensional electron density inversion approach named “NeXtYZ” to produce ionospheric density, ion velocity, and tilt of the ionization in the bottomside ionosphere based on the list of detected radio echoes with their physical parameters. Sometimes, the resulting density profiles can be erroneous, not reflecting real ionosphere, probably due to severely disturbed

ionosphere in the polar region. In this study, the automatic classification procedure of the estimated electron density profiles is developed to filter out unusable data for the 5-year period from 2017 to 2021. The ionograms are classified into four categories: ‘Unavailable’, ‘Sporadic E’, ‘Needs Reprocessing’, and ‘Available’. It is found that approximately 50% of ionograms are evaluated to be reasonable with proper electron density profiles and about 35% of them tend to be affected by sporadic-E like structures, blocking the F-region ionosphere to be observed. It should be noted that the sporadic-E like structures in the polar ionosphere seems to be main obstacles for the ionospheric sounding observation of the F-region ionosphere. Only less than 10% of ionograms are classified as a reprocessing type which needs to be reprocessed. Finally, no echoes are recognized by Dynasonde analysis for about 5% of ionograms. The reprocessing and/or unavailable types might be associated with auroral precipitations that disturbs the ionosphere in the polar region.

keywords:
ionogram; Vertical Incidence Pulsed Ionospheric Radar (VIPIR); Dynasonde; polar ionosphere

1-12

Geosciences, Multidisciplinary; Oceanography; Paleontology

Climate, Fjord Morphology, and Oceanographic Controls on Glacier Retreat and Sedimentation in Bellsund, Southwestern Svalbard

Joe, Young Jin., Jang, Kwangchul., Ahn, Youngkyu., Forwick, Matthias., Laberg, Jan Sverre., Vogt, Christoph Martin., Xiao, Xiaotong., **Son, Yeong Ju., Kim, Jung-Hyun.** and **Nam, Seung-II.**
Paleoceanography and Paleoclimatology. 2025. 40(9).
doi: 10.1029/2025pa005207.

We investigate subbottom acoustic data combined with sedimentology and stratigraphy from a 470 cm-long sediment core from Bellsund, southwestern Svalbard, to reconstruct glacier dynamics and environmental change since the last deglaciation. Our results indicate that a marine-based glacier occupied Bellsund around 15 ka BP, subsequently retreated, with a temporary stillstand near the inner basin around 14

ka BP. By the onset of the Younger Dryas (YD), the glacier fronts had reached the mouths of the tributary fjords. Notably, glacier retreat in Bellsund progressed more slowly than in the adjacent Isfjorden, most likely due to topographic constrictions at the mouths of its tributary fjords (e.g., Eholmen and Aksel & oslash;ya), which acted as pinning points. No evidence is found for glacier re-advance during the YD. Following the YD, rapid glacier retreat into the tributary fjords contributed to meltwater discharge and terrestrial input, which in turn was associated with glacier-distal, glacialmarine sedimentation with reduced ice rafting until 10.7 ka BP. During the early to middle Holocene (9.5–3.3 ka BP), Bellsund experienced a condensed sedimentary environment, likely reflecting the combined influence of intensified bottom current activity driven by Atlantic Water inflow, relative sea-level fall due to glacio-isostatic uplift, and local bathymetric highs. Since 3.3 ka BP, glacial influence in Bellsund has been dominated by input from the adjacent southern tributary fjord (Recherchefjorden). Our findings highlight the interplay of climate forcing, fjord morphology, and oceanographic processes in shaping glacier behavior and environmental change in glaciated Arctic fjord systems.

keywords:

Svalbard; Bellsund; fjord morphology; glacier; depositional environment; provenance

1-13

Meteorology & Atmospheric Sciences

Climatic Characteristics and Complementarity of Solar and Wind Energy in Korea: Potential Benefits of Hybrid Power Generation for Mitigating Energy Droughts

Choi, Jung., Son, Seok-Woo. and Jun, Sang-Yoon.
Atmosphere. 2025. 35(3): 315–329.
doi: 10.14191/Atmos.2025.35.3.315.

With the growing adoption of renewable energy sources, it has become increasingly important to address the risks of solar and wind energy droughts. This study examines the spatiotemporal characteristics of solar and wind energy resources across six administrative districts in Korea, using 63 years of hourly reanalysis data at a 25 km resolution. The results show that solar energy resources, despite having lower overall availability compared to offshore wind energy resources, experience fewer

energy drought days and have a more uniform distribution across inland regions. Conversely, the offshore wind energy resources offer higher availability but exhibit greater regional diversity and more frequent energy drought events. While both resources show small interannual variability, they exhibit significant seasonal fluctuations, with availability varying by a factor of two to three depending on the season and region. Notably, solar and offshore wind energies complement each other seasonally, contributing to enhanced daily availability in summer and improved intra-day stability in winter. This complementarity reduces the frequency of energy droughts in hybrid energy systems that combine both resources. This result highlights the potential benefits of solar-wind hybrid power plants-integrating distributed solar systems with offshore wind farms-to improve both resource availability and supply stability.

keywords:

Renewable energy availability; Renewable energy variability; Renewable energy drought; Solar-wind hybrid power plants

1-14

Meteorology & Atmospheric Sciences

Combined Influence of IPO and AAO on Dust Events in South America

Shi, Cuicui., Mao, Rui., Kim, Seong-joong. and 3 others.
Journal of Climate. 2025. 38(22): 6661–6676.
doi: 10.1175/jcli-d-25-0039.1.

Southern South America is an important dust source to Antarctica. However, there is a lack of overall understanding of the dust event variation in recent decades in South America. Here, we analyzed variations in the dust frequency in southern South America (south of 20°S) from 1986 to 2020 and its causes with large-scale climatic factors, based on observational station data and reanalysis data. During the austral spring and summer, several stations recorded an average dust frequency exceeding 15 days, with some even surpassing 20 days. The frequency of dust events in spring exhibited a strong association with large-scale climate factors. Negative phases of the interdecadal Pacific oscillation (IPO) and the Antarctic Oscillation (AAO) were more likely to lead to an increase in the dust frequency in southern South America. The negative IPO had a greater impact on the Patagonia dust (south of 40°S), resulted from a decrease in

the drought index under the influence of downward motion. However, the negative AAO had a greater impact on the dust in South America over 20°–40°S by increasing strong wind frequency and decreasing the drought index over there. On longer time scales, model outputs from the Coupled Model Intercomparison Project phase 6 (CMIP6) also confirmed the combined influence of the negative IPO and negative AAO phases on southern South American dust.

keywords:

South America; Antarctic Oscillation; Dust or dust storms; Pacific decadal oscillation

1-15

Chemistry, Multidisciplinary; Crystallography; Materials Science, Multidisciplinary

Crystallization Mechanisms of Porous and Compact Amorphous Solid Water Films

Lee, Du Hyeong. and Kim, Kitae.
Crystal Growth & Design. 2025. 25(4): 978–985.
doi: 10.1021/acs.cgd.4c01284.

Amorphous solid water (ASW), formed by vapor deposition on cryogenic substrates (<130 K), transforms into crystalline ice at high temperatures. However, some aspects of the crystallization mechanism, such as the nucleation process, remain unclear. In this study, the crystallization kinetics of porous ASW (pASW) and compact ASW (cASW) were evaluated to identify their nucleation sites. ASW films were grown under ultrahigh vacuum conditions by background and tube-doser deposition, and their porosities were controlled by adjusting the deposition temperature and angle. In addition, the crystallized fractions were measured using desorption spectrometry. The results reveal that the pASW crystallization is triggered within the film interior, whereas the nucleation of cASW films occurs on their surfaces. Owing to the presence of pores, the pASW films crystallize faster than the cASW ones, and the crystallization activation energy of the former (68.9 kJ mol^{−1}) is lower than that of the latter (79.8 kJ mol^{−1}). These findings highlight the role of porosity in the crystallization of ASW, providing insights into the behavior of water molecules in cryogenic environments including polar atmospheres and the surfaces of planets and satellites.

1-16

Engineering, Electrical & Electronic; Geography, Physical; Remote Sensing; Imaging Science & Photographic Technology

Data Assimilation of Satellite-Derived Arctic Sea-Ice Thickness During Boreal Summer

Lee, Jeong-Gil., Kang, Daehyun., Kim, Joo-Hong., Kim, Jong-Min. and 3 others.
IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing. 2025. 18: 11330–11341.
doi: 10.1109/jstars.2025.3561257.

Reliable estimation and initialization of Arctic sea-ice thickness (SIT) through data assimilation (DA) during the summer melt season were previously hampered by the lack of available observations owing to limitations in satellite retrieval algorithms. Recently, successful satellite-derived Arctic SIT measurements from CryoSat-2 (CS2) and advanced microwave scanning radiometer 2 (AMSR2) during the boreal summer have been achieved using advanced retrieval algorithms. This study compares the impacts of CS2 and AMSR2 SIT datasets by individually assimilating each dataset using the ensemble optimal interpolation DA technique with CICE 5 dynamical sea-ice model in 2019 and 2020. The underestimated sea-ice extent in the control simulation without DA during summer was effectively corrected in the reanalysis assimilating AMSR2. However, the degree of correction was less pronounced in the reanalysis assimilating CS2. A sensitivity experiment confirmed that the weak correction degree when using CS2 was not due to its low spatiotemporal resolution, suggesting that the issues may arise from a systematic negative bias related to ice roughness over the central Arctic Ocean in CS2. During the summer and subsequent sea-ice growing seasons, the simulated SIT in the DA of AMSR2 shows greater similarity with independent reanalysis and satellite data than that of CS2. Validations against SIT observations measured by ice mass balance and upward-looking sonar indicate that the DA of AMSR2 effectively enhances the day-to-day variability compared with CS2 and control simulations during both the summer and subsequent winter seasons. This study underscores the response of the model to assimilating current satellite summer SIT data and highlights the factors to consider when utilizing these data.

keywords:

Sea ice; Atmospheric modeling; Arctic; Predictive models; Satellites; Data models; Accuracy; Snow; Earth; Sea

measurements; Advanced microwave scanning radiometer 2 (AMSR2); CryoSat-2 (CS2); data assimilation (DA); sea-ice thickness (SIT); summer sea ice

1-17

Development and Evaluation of a Ground CO₂ Measurement System

Park, Keunbo.
Journal of the Korean Geotechnical Society. 2025.
doi: 10.7843/kgs.2025.41.6.297.

Demand has increased for field-deployable, high-precision instruments to quantify CO₂ exchange at the permafrost-atmosphere interface. To meet this need, we developed a CO₂ analyzer based on non-dispersive infrared (NDIR) spectroscopy integrated with an MCU-based controller, a real-time compensation algorithm, a communication module, and a GUI-based visualization system to ensure stable field operation. The system incorporates zero and span calibrations with standard gases, moving-average and adaptive signal filtering, anomaly detection, and continuous data logging to improve robustness. Performance was evaluated using CO₂ standards at 0.600 ppm, 429.86 ppm, and 953.55 ppm; metrics assessed included accuracy, precision, response time, linearity, and zero stability. Experimental results show close agreement with reference concentrations across the tested range and performance comparable to a commercial high-precision system (LI-COR LI-7810), including accuracy within ±1%, precision better than 0.560, and minimal long-term zero drift. A 1:1 comparison confirmed excellent linearity and high correlation between the instruments.

keywords:
Permafrost; Greenhouse gas; Carbon dioxide; Nondispersive infrared CO₂ sensor; Sensor controller

1-18

Diatom Research to Interpretation
Paleoenvironmental Changes in Beaufort
Island, Ross Sea, Antarctica

Bak, young-suk., Lee, Jae Il., Yoo, Kyu-Cheul., Kim, Sunghan. and Lee, Min Kyung.
The Journal of The Korean Earth Science Society. 2025. 46(2): 107-114.
doi: 10.5467/JKESS.2025.46.2.107

Diatoms were analyzed to determine paleoenvironmental changes in core sediments obtained near Beaufort Island in the Ross Sea. A total of 57 species belonging to 27 genera were identified from the RS19-GC09, and the number of diatom valve abundance ranged from 0.01 to 28.75 × 10⁷/g. Four assemblage zones were established based on the vertical distribution curves of diatom. The occurrence of sea ice species (TC; *Fragilariopsis curta*, *F. linearis*, *F. obliquecostata*, *F. ritscheri*, and *Pseudo-nitzschia turgiduloides*) and open water species (TW; *F. kerguelensis*, *Thalassiosira lentiginosa*, *T. antarctica*, and *Rhizosolenia styliformis*) was compared with magnetic susceptibility (MS) and total organic carbon (TOC) values. Diatom assemblage zone I showed a high MS curve, contrary to low TC, TW, and TOC corresponding to heavy sea-ice or sub-ice shelf conditions. Diatom assemblage zone II showed high TC, increasing TW and TOC values, and conversely, decreasing MS values indicating a long duration of seasonal sea-ice and an expanded distribution. Diatom assemblage zone III showed decreased TC, high TW and TOC, and the lowest MS curve, indicating a long period in an open water environment. Diatom assemblage zone IV showed a period of decreasing TW, conversely increasing TC, noticeable change in TOC, and slightly increasing MS, again indicating a period of long sea-ice duration.

keywords:
Diatom; Ross Sea; Assemblage zone; Sea-ice species; Open water species

1-19 Meteorology & Atmospheric Sciences

Disappearance of the El Niño-driven surface mass gain in West Antarctica under future climate change

Lee, Hyun-Ju., Jin, Emilia Kyung., Kim, Byeong-Hoon. and Lee, Won Sang.
Npj Climate and Atmospheric Science. 2025. 8(1).
doi: 10.1038/s41612-025-01174-x.

Strong El Niño events drive substantial snowfall in West Antarctica, including the Antarctic Peninsula, by weakening the Amundsen Sea Low (ASL) through atmospheric teleconnections, increasing surface mass balance, and mitigating ice mass loss's contribution to sea-level rise. However, we find that CMIP6 projections show a diminishing El Niño-driven precipitation effect as global warming intensifies. The El Niño-associated precipitation anomaly is projected to weaken in SSP3-7.0 and SSP5-8.5, becoming indistinguishable from zero by the late 21st century in the latter. This transition is caused by a strengthened polar jet, linked to a positive Southern Annular Mode (SAM) trend in a warmer climate, which extends the wavelength of Rossby waves. As a result, the ASL anomaly eventually migrates eastward and equatorward, reducing water vapor transport into West Antarctica's interior. These findings indicate that El Niño-driven precipitation disappears in a high-emission future, eliminating one of the buffering mechanisms that help counteract sea-level rise.

1-20 Multidisciplinary Sciences

East Siberian ice wedges recording dust transport variability during the Late Pleistocene

Kim, Soyeon., Lee, Hyunwoo., Kim, Jeongmin., Lee, Yuyoung., Choi, Jeong-Heon., Lee, Mi Jung. and 7 others.
Nature Communications. 2025. 16(1).
doi: 10.1038/s41467-025-65772-2.

During the Late Pleistocene, a severely cold and dry climate strengthened dust production across the Northern Hemisphere. Despite many studies examining aridification and dust production, there is a lack of understanding about dust transportation during global climate variability. Long-range transported (LRT) dust can be traced by comparing global geochemical signatures and constraining provenance relationships. Here we report rare earth element abundances and strontium, neodymium, and oxygen isotope compositions of inorganic substances in ice wedges from Batagay and Central Yakutia (Cyuie and Churapcha), which comprise Yedoma deposits that formed in unglaciated Beringia. Distinct geochemical properties reflect differences between local and LRT dust contributions. Particles in the Batagay ice wedges show higher similarities to Chinese aeolian deposits, while

those in Central Yakutia indicate stronger local input. These provenance constraints highlight variability in atmospheric circulation transporting dust to the Arctic during the Late Pleistocene, linking climate changes to aerosol distribution.

1-21 Engineering, Electrical & Electronic; Geography, Physical; Remote Sensing; Imaging Science & Photographic Technology

Enhancing Passive Microwave Brightness Temperature Using Dual-Attention SRGAN

Chi, Junhwa., Park, Jinku. and Kim, Hyun-Cheol.
IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing. 2025. 18: 22784-22797.
doi: 10.1109/jstars.2025.3603856.

This study presents a dual-attention super-resolution generative adversarial network (DA-SRGAN) framework to enhance the spatial resolution of passive microwave (PMW) brightness temperature (TB) data from 12.5/25 km to 3.125/6.25 km. By integrating channel and spatial attention mechanisms into the SRGAN architecture, the proposed model prioritizes critical low- and mid-frequency features inherent to PMW measurements, effectively suppressing noise while preserving radiometric accuracy and geophysical structures, such as atmospheric fronts, precipitation bands, and coastlines. Quantitative evaluations demonstrate DA-SRGAN's superiority over baseline models (SRCNN, SRGAN) across metrics including MAE, RMSE, SSIM, and LPIPS, with cosine similarities exceeding 0.995 in histogram-based distribution comparisons. Cross-sensor validation with AMSR2 89 GHz data demonstrates the model's ability to maintain statistical relationship between sensors at enhanced spatial resolution despite hardware and frequency differences. Spatiotemporal consistency analysis across diverse environmental conditions reveals robust performance with RMSE values consistently below 1 K across all surface types and seasons, demonstrating temporal stability and regional consistency. Exploratory assessment at finer resolution (3.125/6.25 km) confirms effective spatial detail enhancement while preserving statistical distribution integrity. These advancements position DA-SRGAN as a transformative tool for bridging resolution gaps in PMW satellite remote sensing, offering improved observational fidelity for environmental applications.

keywords:
Dual-attention mechanisms; generative adversarial networks (GANs); noise suppression; passive microwave (PMW) brightness temperature (TB); super-resolution (SR);

1-22 *Geography, Physical; Geosciences, Multidisciplinary*

Establishing a well-constrained chronology of an ice core from the Styx glacier, northern Victoria land, east Antarctica, to reconstruct long-term snow accumulation variability

Ro, Seokhyun., Han, Yeongcheol., Hur, Soon Do., Kim, Songyi., Chang, Chaewon., Moon, Jangil., Han, Changhee., Hong, Sang-Bum. and Hong, Sungmin.
Journal of Glaciology. 2025. 71.
doi: 10.1017/jog.2025.10074.

In this study, we established an annually resolved chronology for the upper 98.5 m of a 210.5 m deep ice core (Styx-M core) drilled at the Styx Glacier plateau (SGP) in northern Victoria Land, East Antarctica, to reconstruct the multi-centennial variations of the snow accumulation rate (SAR). The core was dated via the annual layer counting of highly resolved impurities exhibiting seasonal cycles. The layer counting result was constrained using multiple temporal markers, including the 239Pu peaks that resulted from atmospheric weapon tests as well as five large volcanic eruptions in recorded history. These approaches show that the Styx-M core chronology covered 755 years (1259–2014 CE), with the estimated dating uncertainties of ± 8 years. The annual accumulation record was derived using the depth-age scale and depth-density relationships of the core. This record revealed a long-term trend of a ~30% increase in the SARs over the past 755 years, overlapping the pronounced inter-decadal and multi-decadal fluctuations. Further study will be needed to reveal the complex interaction of oceanic and atmospheric processes controlling the temporal fluctuations of SARs in the coastal areas of northern Victoria Land, combining multiple proxy records in the Styx-M core.

keywords:
Annual layer counting; Chronology; Snow accumulation rate; Styx Glacier; Styx-M ice core

1-23 *Meteorology & Atmospheric Sciences*

Evaluation of NCEP Global Forecasting System (GFS) Performance in Predicting Landfalling Tropical Cyclone Rainfall in South Korea

Hwang, Jiwon., Cha, Dong-Hyun., Lee, Minkyu., Yoon, Donghyuck., **Choi, Yonghan.** and Ito, Kosuke.
Weather and Forecasting. 2025. 40(6): 875–888.
doi: 10.1175/waf-d-24-0162.1.

This paper discusses the performance of the National Centers for Environmental Prediction (NCEP) Global Forecast System (GFS) forecast model in predicting rainfall over the Korean Peninsula caused by tropical cyclones (TCs). TCs forecasted in GFS were characterized by overestimated intensity and a well-organized inner-core structure during landfall, and the associated TC-induced rainfall forecast errors were examined from two perspectives: TC tracks and TC-environmental interactions. The results provide implications in three ways. First, the predicted TC track is biased to the west, bringing it closer to the Korean Peninsula landmass and contributing to an overall increase in overland precipitation. Second, the strongly simulated TC during landfall predicted rainfall only in a narrow radius around the TC center. Third, the TCs were characterized by a weak upper-level TC outflow due to the well-developed TC structure, which could increase the inertial stability of the TC center during jet interaction, leading to an underestimated precipitation in the outer-core region of the storm. These results suggest specific sources of error in the forecast of TC precipitation over the Korean Peninsula, which can contribute to improving numerical models and providing forecasters with information about model characteristics. SIGNIFICANCE STATEMENT: This study evaluates the performance of the National Centers for Environmental Prediction (NCEP) Global Forecast System (GFS) in forecasting precipitation from tropical cyclones (TCs) over the Korean Peninsula. The GFS model tends to overestimate the intensity and depict a more well-developed structure of these TCs during landfall, leading to three key issues. First, there is a westward bias in TC track prediction, resulting in increased overland rainfall. Second, the model shows a concentrated rainfall distribution around the center of TCs. Third, there is a lack of upper-level outflow in the model, underestimating rainfall in the TC outer-core regions due to poor TC-jet interaction forecasts. These insights highlight specific errors in the model and provide guidance for improving future forecasts.

keywords:
Rainfall; Tropical cyclones; Forecast verification/skill; Model errors; Model evaluation/performance; Numerical weather prediction/forecasting

1-24 *Geosciences, Multidisciplinary*

Evidence of methanogenic activity associated with past fish farming in Lake Soyang, South Korea

Lee, Dong-Hun., **Kim, Jung-Hyun.**, Kang, Sujin., **Kim, Dahae.** and Shin, Kyung-Hoon.
Progress in Earth and Planetary Science. 2025. 12(1).
doi: 10.1186/s40645-025-00700-y.

In this study, a 54-cm-long sediment core was collected from an area with a history of fish farming to investigate a potential link between methane production and past aquaculture activities in Lake Soyang, a large artificial lake (ca. 2–110 m water depth, 16.08 km(2) in area). Along with bulk elements (carbon and nitrogen), we analyzed specific lipid biomarkers, including n-alkanes, sterols, glycerol dialkyl diethers (DGDs), and glycerol dialkyl glycerol tetraethers (GDGTs). Additionally, we measured the compound-specific carbon isotopic composition ($\delta^{13}\text{C}$) of specific lipids, excluding GDGTs. Evidence of prior aquaculture activities was indicated by high total organic carbon content (~30 wt%) and elevated concentrations of coprostanol and stigmasterol, reflecting substantial deposition of mixed organic matter (OM) from aquaculture practices, such as fish feed and feces. The $\delta^{13}\text{C}$ values of sterols (– 28.4 ± 1.4 parts per thousand) were relatively enriched compared to those of isoprenoid DGDs, such as archaeol and OH-archaeol (– 40.0 ± 3.2 parts per thousand). This suggests that increased acetoclastic methanogenic activities may be closely linked to the assimilation of by-products derived from aquaculture-related OM as potential carbon sources. Our findings highlight the potential importance of methane production within aquaculture systems and the environmental factors influencing this process. These results could inform the development of systematic management strategies to mitigate methane emissions from aquaculture systems.

keywords:
Aquaculture; Organic matter; Methanogenesis; Lipid biomarker; Compound-specific isotope analysis; Eutrophication

1-25 *Geosciences, Multidisciplinary*

Geochemical charactersitscs of meltwaters collected at Longyearbyen, Arctic Svalbard: Feedback linking glacial melting, chemical weathering and carbon cycle

Ryu, Jong-Sik., Lim, Hyoun Soo., Park, Hojin. and **Ok-Sun, Kim.**
Journal of the Geological Society of Korea. 2025. 61(2): 159–170.
doi: 10.14770/jgsk.2025.006.

Glacial meltwater, once considered a passive component in the global carbon cycle, has recently been recognized as a potentially significant factor. This study investigates the feedback mechanisms of glacial meltwater on the carbon cycle through an analysis of major ions and magnesium isotopes in meltwater samples collected from Longyearbyen, Svalbard. The major ion composition revealed elevated concentrations of calcium, magnesium, bicarbonate, and sulfate, typical of glacial meltwater, along with high sodium concentration. Using chemical weathering pathways and mass balance calculations, the contribution of sulfuric acid-carbonate weathering (SACW) was determined to be 28.4± 8.53% (1σ, n=11), sulfuric acid-silicate weathering (SASW) at 42.3±12.6% (1σ, n=11), carbonic acid-silicate weathering (CASW) at 11.1±13.7% (1σ, n=11), and carbonic acid-carbonate weathering (CACW) at 8.84±7.52% (1σ, n=11). These results indicate that the meltwater in the study area is primarily influenced by sulfide oxidation, incongruent silicate dissolution, and carbonate dissolution, a finding supported by variations in magnesium isotope composition. The chemical weathering rates (W) for each weathering pathway were calculated as follows: WSACW = 4.26±2.45 t/km²/yr (1σ, n=11), WSASW = 2.75±1.58 t/km²/yr (1σ, n=11), WCASW = 0.40±0.52 t/km²/yr (1σ, n=11), and WCACW = 1.03±0.96 t/km²/yr (1σ, n=11). The average CO₂ consumption rate for the lowermost stream samples was 4.13 × 10⁵ mol/km²/yr. However, on a geological timescale, the net carbon cycle due to chemical weathering in the entire study area was calculated to be –3.40 × 10⁵ mol/km²/yr (–15.0 t CO₂/km²/yr), indicating an annual release of 15 tons of carbon dioxide into the atmosphere. This study suggests that glacial melt exerts a positive feedback on the global carbon cycle and highlights the importance of considering sulfide mineral weathering, in addition to silicate mineral weathering, in future research on glacial weathering-carbon cycle feedback mechanisms.

keywords:
carbon cycle; positive feedback; chemical weathering; sulfide mineral; glacial melt

1-26 **Geography, Physical; Geosciences, Multidisciplinary**

Glacier area variation in Uttarakhand Himalaya: Investigating trends and influencing factors

Shrivas, Iti., **Guha, Supratim**. and 3 others.
Earth Surface Processes and Landforms. 2025. 50(1).
doi: 10.1002/esp.6072.

Understanding the intricate interplay between topography and glacier changes is vital for predicting future water resources and addressing the impacts of climate change. This study examines changes in glacier area in the Uttarakhand Himalayan region, where the River Ganga originates, between 2000 and 2023 using high-resolution satellite imagery. A manual digitization process was employed to delineate the glacier boundaries of 116 glaciers for the years 2000 and 2023. Multivariate regression analysis was then conducted to identify and quantify the controlling topographical and morphological parameters. The analysis revealed significant reductions in total glacier area, decreasing from 979.05 ± 46.89 km² in 2000 to 957.60 ± 13.67 km² in 2023, with an overall deglaciation rate of 0.095% per year, highlighting variability in glacier responses. This variability is driven by a complex interplay of mainly slope, shape index, glacier elevation and surface ice velocity. Among these factors, the shape index emerged as the most influential. Glaciers with a higher shape index (more elongated) were found to be more stable than those with a lower shape index (more circular). A 10% difference in shape index results in a glacier with a higher shape index losing 0.112% per year less area compared to a glacier with a lower shape index. The second controlling parameter is glacier slope; glaciers with a 10% steeper slope lost 0.11% per year less area compared to those with a gentler slope. The other two parameters showed some minor impact on glacier area variation in the sample glaciers but not across the entire Uttarakhand region.

keywords:
Central Himalaya; debris cover; glacier area change; multivariate regression; shape index; topographical and morphological analysis

1-27 **Geography, Physical; Geosciences, Multidisciplinary; Paleontology**

Glaciovolcanic processes between the Campbell Glacier and Mt. Melbourne Volcano, Antarctica: ICE and FIRE

Rhee, Hyun Hee., **Lee, Min Kyung**., Seong, Yeong Bae., **Kim, Sunghan**., **Lee, Jae Il**., **Yoo, Kyu-Cheul**. and Yu, Byung Yong.
Palaeogeography Palaeoclimatology Palaeoecology. 2025. 657.
doi: 10.1016/j.palaeo.2024.112611.

This study investigates the glacial dynamics of the Campbell Glacier in Terra Nova Bay (TNB), Antarctica, with a focus on its unique lowering patterns during the late Quaternary. Using cosmogenic nuclides (10Be) surface exposure dating, we provide significant chronological constraints on Antarctic terrestrial glacier changes. In addition to the previous data on Marine Isotope Stage (MIS) 5 simple exposure ages of Campbell Glacier moraines, we further analyzed the palaeo-subglaciated bedrock, which yields exposure ages during MIS 3 and 2 (49.8–28.5 ka). Our analysis empowers that continuous glacial lowering occurred throughout the late Quaternary, even during the Last Glacial Period (MIS 4–2), and that the Local Last Glacial Maximum (LLGM) occurred at 150–90 masl during MIS 4 rather than MIS 2. This new and recalculated dataset for the Campbell Glacier is unique compared to other outlet glaciers flowing into the Terra Nova Bay, highlighting the significant influence of Mt. Melbourne’s volcanic activity via glaciovolcanic processes during the late Quaternary, beyond general climatic and oceanic factors. Further studies of palaeo-glaciovolcanic interactions on the East Antarctic Ice Sheet (EAIS) promise to provide more robust insights for refining models predicting future accelerated glacial melt and sea level rise, particularly considering the numerous volcanoes beneath the West Antarctic Ice Sheet (WAIS).

keywords:
Glaciovolcanic Process; Local Last Glacial Maximum; Cosmogenic nuclides surface exposure dating; Campbell glacier; Mt. Melbourne Volcano

1-28

High-Precision Multi-Sensor Digital Surface Model Dataset Based on UAV and Satellite Data for Greenland Glacier Monitoring

Jeong, Yongsik. and **Kim, Hyun Cheol**.
Geo Data. 2025.
doi: 10.22761/gd.2025.0059.

This study presents a methodological framework for developing a high-precision digital surface model (DSM) dataset based on complementary unmanned aerial vehicle (UAV) light detection and ranging (LiDAR) and satellite-derived data for Russell Glacier terminus, Greenland. Field surveys were conducted across four annual campaigns (2022–2025), acquiring UAV LiDAR data that were subsequently cross-referenced with three satellite-derived DSMs, ASTER GDEM V3, WorldDEM, and Arctic- DEM Mosaic v4.1. Vertical rectification using inverse distance weighting interpolation with six ground control points was applied to all datasets, achieving a remarkable 94.1% improvement in accuracy, reducing mean root mean square error (RMSE) from 19.05 to 1.12 m. WorldDEM demonstrated the most substantial improvement (98.6% reduction), while post-correction ArcticDEM achieved the highest accuracy (0.20 m RMSE). UAV LiDAR maintained centimeter-level precision (0.51 m RMSE). Spatiotemporal analysis revealed significant morpho-dynamic changes, including proglacial lake expansion, moraine evolution, and surface elevation variations. Over 20 years (2000–2025), terminus-region elevation differences reached to 20 m. The vertical rectification methodology demonstrates the effectiveness of employing multi-sensor datasets derived from complementary platforms to overcome individual sensor limitations. This dataset supports glacier mass balance research, dynamics investigations, and climate change impact assessments. The dataset is publicly available through the Korea Polar Data Center (KPDC).

keywords:
Greenland; Russell Glacier; Digital surface model; Unmanned aerial vehicle LiDAR; Vertical correction

1-29

Geochemistry & Geophysics

Holocene climate driving spatially variable mercury input to an Arctic fjord environment (vol 695, 123043, 2025)

Son, Eun Jin., Lee, Ju Hyeon., Jang, Kwangchul., **Ahn, Youngkyu**., Knies, Jochen., Forwick, Matthias., **Kim, Jung-Hyun**., **Nam, Seung-Il**. and Kwon, Sae Yun.
Chemical Geology. 2025. 695.
doi: 10.1016/j.chemgeo.2025.123043.

Mercury (Hg) is a globally distributed pollutant, affecting the Arctic through ocean and atmospheric circulation, coastal erosion, and riverine export from continents. We employ Hg stable isotopes and geochemical proxies to evaluate how climatic variation over the Holocene has influenced Hg sources in Arctic fjord environments. Hg isotopes measured in four sediment cores from western Svalbard are compared to gather insights into spatiotemporal variability of Hg sources and depositional history. Compared to other pre-industrial marine sediments, which are primarily influenced by wet deposition (precipitation) and terrestrial runoff, Hg sourced from bedrock erosion and Hg bound to particulate organic matter (pHg) transported by Atlantic Ocean currents are the dominant Hg sources to the Svalbard fjords. The temporal profiles of these two Hg sources vary spatially, with Kongsfjorden showing greater bedrock-Hg around 12.6 ka BP, while Woodfjorden and Dicksonfjorden exhibit higher influences at 8 ka and 4 ka BP, respectively. Despite these temporal differences, colder periods are generally dominated by Hg sourced from bedrock, whereas warmer periods are characterized by the contribution of pHg. In modern times, global anthropogenic activities have widespread Hg influences, whereas regional activities such as coal mining have little Hg influence. Our study highlights the importance of regional environmental setting and the global rise in anthropogenic activities in determining the spatiotemporal variation in Hg sources in Arctic over the Holocene. The findings provide insights into complex interactions between climate change and the Hg cycle in an Arctic fjord ecosystem.

keywords:
Svalbard; Stable isotopes; Sediment core; Glacial dynamics; Marine productivity

1-30

Oceanography

Ice Shelf Water-Influenced Fast Ice and Sub-Ice Platelet Layer Near the Campbell Ice Tongue, Terra Nova Bay

Brett, Gemma Marie., Gardiner, Natasha., Langhorne, Pat., Rack, Wolfgang., Haas, Christian., Irvin, Anne. and Kim, Sanghee.
Journal of Geophysical Research–Oceans. 2025. 130(11).
doi: 10.1029/2024jc021342.

Here, we present the first dedicated in situ measurements of the thickness distributions of fast ice and the sub-ice platelet layer, formed by supercooled Ice Shelf Water in north Terra Nova Bay, Antarctica. With the objective of inferring source regions and circulation of Ice Shelf Water, we measured fast ice and sub-ice platelet layer thickness distributions near the Campbell Ice Tongue in late spring of 2021, using drill hole surveys and high-resolution ground-based electromagnetic induction soundings. We observed thicker fast ice and sub-ice platelet layer near the ice tongue with very thick and narrow sub-ice platelet layer maxima indicating highly channeled outflow of supercooled Ice Shelf Water from beneath the ice tongue directed by ice mélange, subglacial formations, and grounded regions. We conclude that a significant volume of supercooled Ice Shelf Water is locally sourced from the Campbell Ice Tongue through basal melting and affirm that the icescape in north Terra Nova Bay results from a complex interplay of glacial morphology, polynya forcing, and ocean circulation.

keywords:
land-fast sea ice; sub-ice platelet layer; ice tongue; ice-ocean interactions; Antarctic coastal zone; electromagnetic induction

1-31

Geography, Physical; Geosciences, Multidisciplinary

Identification of 320 000-year-old blue ice at the surface of the Elephant Moraine region, East Antarctica

Lee, Giyeon., Ahn, Jinho., Ju, Hyeontae., Oyabu, Ikumi., Ritterbusch, Florian., Kim, Songyi., Moon, Jangil., Lee, Joohan., Han, Yeongcheol., Hur, Soon Do. and 4 others.
Cryosphere. 2025. 19(8): 3295–3308.
doi: 10.5194/tc-19-3295-2025.

To address important paleoclimatic questions, such as the cause of the Mid-Pleistocene Transition (MPT), the search for 1-million-year-old ice is of great interest. Antarctic blue-ice areas (BIAs), where ancient ice outcrops on the surface of ice sheets, offer promising sites for identifying ice spanning the MPT period. To date, only two sites, the Allan Hills BIA and the Mullins Glacier in East Antarctica, have been identified as areas that contain ancient ice older than 1 million years. We investigated icefields in the Elephant Moraine and Reckling Moraine regions of East Antarctica to contribute to the search for ancient ice spanning the MPT. Ice-penetrating radar surveys revealed that ice thickness ranged from 200 to 800 m across the icefields. ⁸¹Kr dating of the surface ice (< 10 m) showed ages of 83–119 kyr BP (before present) and 93–124 kyr BP for blue ice in the Meteorite City Icefield and 320–385 kyr BP in the Elephant Moraine Main Icefield. We also analyzed several gas compositions ($\delta^{15}\text{N-N}_2$, $\delta^{18}\text{O-O}_2$, $\delta\text{O}_2 / \text{N}_2$, $\delta\text{Ar} / \text{N}_2$, CO_2 , CH_4 , and N_2O) and revealed that gas records at very shallow depths are altered. A comparison of stable water isotopes ($\delta^{18}\text{O-ice}$ and $\delta^2\text{H-ice}$) indicated that the original deposition site of the Elephant Moraine Main Icefield experienced colder conditions than those of the nearby icefields. Given these findings, ice spanning the MPT period could be retrieved from the Elephant Moraine Main Icefield with only a few hundred meters of drilling.

1-32

Meteorology & Atmospheric Sciences

Impact of Arctic Sea Ice Representation on Extended Medium-Range Forecasting: a Case Study of the 2016 Barents-Kara Sea Warming Event

Park, Jung Hyun. and 9 others.
Asia-Pacific Journal of Atmospheric Sciences. 2025. 61(1).
doi: 10.1007/s13143-024-00387-z.

In early January 2016, Storm Frank, an extreme winter storm with a peak intensity of 928 hPa, intruded into the Atlantic sector of the Arctic. This led to unprecedented warming and significant sea ice loss in the Barents–Kara (B–K) Sea. Following this extreme warming event, a series of extreme weather events occurred in mid- and late-January across Eurasia, including a persistent blocking pattern near the Ural mountains and extreme cold wave events over Mongolia, China, and Korea. This study utilizes the Korean Integrated Model (KIM), coupled with an ocean–sea ice model, to reproduce this event and to examine its extended medium–range forecasting performance. While the control model effectively captures the initial Arctic warming, it struggles to reproduce the observed sustained warming that lasted over two weeks. Here, we identified that the model significantly overestimates the sea ice concentration in the B–K Sea, where the initial warming is more pronounced in observations. Through sensitivity experiments, we found that reducing the sea ice strength parameter, which governs the ice resistance to pressure and deformation, effectively alleviated this overestimation. This adjustment facilitates easier sea ice melting, strengthens the ocean–atmosphere interactions, and extends the duration of simulated Arctic warming. Our findings emphasize the crucial role of accurate Arctic sea ice representation in extended medium–range forecasting for East Asia, particularly for extreme weather events.

keywords:
Coupled KIM; Arctic warming event; Sea ice dynamics; Extended-medium range forecast; Ocean–atmosphere interaction

1-33

Environmental Sciences; Meteorology & Atmospheric Sciences

Impact of strong katabatic wind event variability on sea ice dynamics in Terra Nova Bay Polynya, Antarctica

Xu, Yuanyuan., Mao, Rui., Kim, Seong-Joong. and 2 others.
Environmental Research Letters. 2025. 20(11).
doi: 10.1088/1748-9326/ae06bb.

Polynyas along the Antarctic coastline are essential for sea ice production and the formation of Antarctic Bottom Water (AABW). They are formed and maintained by strong and

persistent katabatic winds that push the ice away from the coast. Satellite data, in-situ meteorological observations and Reanalysis datasets all indicate a decline in sea ice concentration (SIC) over the Terra Nova Bay Polynya (TNBP) from 2013 to 2022, consistent with the occurrence of an increasing trend of strong katabatic wind events (SKWEs). On the interannual timescale, significant correlations between the TNBP area and the duration of SKWEs were observed in austral summer, autumn and winter, and also in April and October during 2003–2022. Sea ice volume budget analysis shows that SKWEs drive rapid sea-ice removal through advection and divergence, whereas thermodynamic processes dominate sea ice formation on an annual basis. The increase in SKWEs was associated with a deepened and southwestward-displaced Amundsen Sea Low (ASL) and an enhanced pressure gradient between the interior plateau and the coast, both potentially linked to a more positive Southern Annular Mode (SAM). These findings provide a mechanistic understanding of long-term polynya variability, with implications for regional sea-ice changes and AABW.

keywords:
Terra Nova Bay Polynya; sea ice concentration; strong katabatic wind events; sea ice volume budget; the Southern annular mode

1-34

Geography, Physical; Geosciences, Multidisciplinary

Imprints of sea ice, wind patterns, and atmospheric systems on summer water isotope signatures at Hercules Névé, East Antarctica

Kim, Songyi., Han, Yeongcheol., Chung, Jiwoong., Ro, Seokhyun., Moon, Jangil., Do Hur, Soon. and Lee, Jeonghoon.
Cryosphere. 2025. 19(11): 5655–5670.
doi: 10.5194/tc-19-5655-2025.

This study investigated the influence of summer climate variability on water isotopes ($\delta^{18}\text{O}$, $\delta^2\text{H}$, and deuterium excess[dexc]) in a Hercules Névé ice core from Antarctica. High-resolution ERA5 reanalysis data for the austral summer (DJF, 1979–2015) were used to assess the relative contributions of temperature, precipitation, wind patterns (v–

and u-winds), ocean condition (sea ice concentration [SIC] and sea surface temperature [SST]), and large-scale circulation system (Amundsen Sea Low [ASL] and Zonal Wave-3 [ZW3]) to isotopic variability. The results show that higher temperatures and precipitation coincide with isotopically enriched $\delta^{18}\text{O}$, confirming their combined role in controlling isotopic enrichment. Wind patterns also contribute meaningfully but in a more complex way: enhanced southerly winds (positive v-wind anomalies) tend to increase $\delta^{18}\text{O}$ by transporting relatively warm, moisture-rich air from lower latitudes, whereas stronger westerly winds (positive u-wind anomalies) are associated with more depleted isotopic values, likely reflecting colder or more distant moisture sources. Additionally, the dexc exhibits a positive correlation with SIC and negative correlations with SST, providing valuable insights into moisture source processes in the study region during austral summer. Variations in the ASL and ZW3 further modulate heat and moisture transport, reinforcing their role as key atmospheric drivers of isotopic variability. Taken together, these findings suggest that the summer isotope record at Hercules Névé reflects not only local temperature changes but also the broader imprint of ocean-atmosphere interactions, including sea-ice variability and large-scale circulation patterns. This study highlights the potential of coastal Antarctic ice cores to provide improved constraints on coupled climate processes and to refine paleoclimate reconstructions for the Ross Sea region.

1-35

Geosciences, Multidisciplinary; Oceanography; Paleontology

Increased Sea Ice Duration in Moubray Bay, Northwest Ross Sea Linked to Early Holocene Wind Strength

Gilmer, Greer., Riesselman, Christina R., **Kim, Sunghan., Yoo, Kyu-Cheul., Lee, Jae Il., Lee, Min Kyung.** and 8 others. *Paleoceanography and Paleoclimatology*. 2025. 40(12). doi: 10.1029/2024pa004930.

Sea ice in the Ross Sea plays a critical role in the formation of dense water masses, ice sheet stability, and air-sea gas exchange, and also supports unique ecosystems. However, its seasonal and spatial variability makes it challenging to include in model simulations. To address this, new sea ice records that extend beyond the satellite era and include

periods of climate change are essential. This new sediment record from Moubray Bay, northwest Ross Sea, reconstructs environmental conditions between ~11,300 and ~10,900 cal yr BP—a time of rapid retreat of marine-based ice sheets and coastal glaciers in the region. The diatom assemblage is dominated by three taxa: *Fragilariopsis curta*, *Corethron pennatum*, and *Chaetoceros* resting spores. Variations in their relative abundances reveal changes in wind strength, water column structure, and sea ice concentration and duration. Between ~11,300 and ~11,200 cal yr BP, environmental conditions are characterized by a stabilized water column due to fresh meltwater influx, and weaker winds, which resulted in shorter sea ice duration and reduced winter sea ice concentration. This continued after ~11,200 cal yr BP but stronger winds linked to deepening of Amundsen Sea Low-like circulation triggered short-term water column stratification. Sea ice concentration and duration increased after ~11,100 cal yr BP driven by cooling of the sea surface by stronger southerly winds. Concurrent changes in early Holocene marine and terrestrial climate records from the Ross Sea indicate a shift in atmospheric circulation during the early Holocene.

keywords:
Ross Sea; sea ice; Holocene; diatoms; Antarctica

1-36

Geosciences, Multidisciplinary

Late Quaternary Glaciations on the Chukchi Margin, Arctic Ocean: Insights From Echo Sounding and Sediment Records

Joe, Young Jin., Polyak, Leonid., Jang, K., Vogt, Christoph Martin., Kim, Sookwan., **Kim, Jung-Hyun., Jin, Young Keun., Hong, Jong Kuk.,** Niessen, F. and **Nam, Seung-Il.** *Journal of Geophysical Research—Earth Surface*. 2025. 130(1). doi: 10.1029/2024jf007703.

Glacigenic bedforms such as glacial lineations and moraines on the Chukchi and East Siberian margins of the Arctic Ocean reveal recurrent waxing and waning of voluminous ice masses. Despite their paleoclimatic significance, the timing, geographic distribution, and mechanisms of these glaciations remain inadequately understood. To enhance our understanding of the Quaternary Arctic glacial history, we

study high-resolution swath bathymetry and subbottom profiler data with lithostratigraphy and provenance of four sediment cores. These data characterize deposits of the last two glaciations at the Chukchi margin and adjacent basins. In all cores, multiple peaks of plagioclase are prominent in both glacial intervals, probably reflecting predominant glacigenic input from the East Siberian Ice Sheet (ESIS). Peaks of dolomite and quartz trace the Laurentide Ice Sheet sources around the last glacial/deglacial interval and in sediment preceding the older glaciation. By integrating seismostratigraphy with sediment cores, we constrain the formation of mid-slope moraines on the western side of the Chukchi Rise to the older glaciation (estimated age range MIS 4 or 6). Considering the coeval glacial erosion off the East Siberian margin, our results confirm that the ESIS at that time extended to water depths of ~650/950 m on the Chukchi Rise/East Siberian margin. In comparison, the last ESIS (MIS 2 or possibly 4) was smaller, with the identified seafloor imprint limited to water depths of ~450 m on the Chukchi Borderland, while its extent on the East Siberian margin remains to be determined.

keywords:
late Quaternary; glaciations; Chukchi margin; East Siberian Ice Sheet; glacigenic bedforms; sediment records

1-37

Geography, Physical; Geosciences, Multidisciplinary; Paleontology

Mid-to-late Pleistocene Depositional Environments at the Ross Sea Continental margin: Implications for Antarctic Ice Sheet Dynamics

Dash, Chinmay., Seong, Yeong Bae., Singh, Ajay Kumar., **Lee, Min Kyung., Lee, Jae Il., Yoo, Kyu-Cheul.** and 2 others. *Palaeogeography Palaeoclimatology Palaeoecology*. 2025. 680. doi: 10.1016/j.palaeo.2025.113355.

This study investigates a sediment core (RS15-LC47) from the Ross Sea continental rise to reconstruct ice sheet dynamics and paleodepositional environments over the past 800 ka. We employed a multi-proxy approach in this study, integrating whole-core magnetic susceptibility (MS), total organic carbon (TOC), calcium carbonate (CaCO₃), biogenic silica,

sedimentological features, and the isotopic ratio of authigenic beryllium ($(^{10}\text{Be}/^9\text{Be})_{\text{reac}}$). The interval between 750 and 550 ka represents an intensified glacial phase characterized by expanded ice sheets, strengthened bottom currents, and reduced marine productivity. The dominance of contourite deposits interspersed with slumped sediments suggests that the sediment deposition occurred under highly dynamic and unstable conditions driven by intensified bottom currents. The presence of poorly sorted sediments and millimetre-scale faults further indicates gravity flow deposition, likely triggered by ice-sheet advances. Low $(^{10}\text{Be}/^9\text{Be})_{\text{reac}}$ ratios in this interval suggest limited scavenging in open marine settings, likely due to reduced sediment transit time to the coring site as advancing ice sheets extended toward the shelf edge. Although TOC values are highest in this interval, a high total organic carbon/nitrogen (TOC/TN) ratio and low excess Barium (Ba_{ex}) suggest increased terrestrial input from the advancing ice sheets and a reduced marine productivity under intense glacial conditions in the Ross Sea. Following the Mid-Pleistocene Transition (MPT), between 550 and 250 ka, MS values remained consistently low, while $(^{10}\text{Be}/^9\text{Be})_{\text{reac}}$ ratios were notably elevated, indicating relatively warmer conditions with diminished glacial influence. The TOC/TN ratios during this interval resemble those observed in the euphotic layer of the Ross Sea, with relatively higher Ba_{ex} and TOC suggesting enhanced marine productivity under relatively warmer conditions between 550 and 250 ka. During the late Pleistocene (>250 ka), the depositional environment became increasingly influenced by glacial-interglacial cycles, with warmer interglacials driving enhanced productivity. During this interval, coarser grain sizes point to stronger bottom currents, while the sharp rise in $(^{10}\text{Be}/^9\text{Be})_{\text{reac}}$ ratios indicates interglacial conditions associated with ice sheet retreat. The longer sediment transit from the subglacial zone to the depositional site during these warmer periods enhanced scavenging of Be isotopes in open marine settings, resulting in elevated $(^{10}\text{Be}/^9\text{Be})_{\text{reac}}$ values. A positive correlation between Opal_{MAR} , TOC%, and $(^{10}\text{Be}/^9\text{Be})_{\text{reac}}$ during interglacials reflects a direct link between increased marine productivity and warmer climatic phases. Our findings emphasize how ice-sheet expansion and retreat control the depositional processes in the region.

keywords:
Ross Sea; Antarctica; Paleoenvironment; Ice sheet; Paleoproductivity; $(^{10}\text{Be}/^9\text{Be})_{\text{reac}}$

1-38

Geosciences, Multidisciplinary

Miocene ice sheet dynamics and sediment deposition in the central Ross Sea, Antarctica

McKay, Robert., Cockrell, Jay., Shevenell, Amelia E., Laberg, Jan Sverre., Burns, Julianne., Patterson, Molly., **Kim, Sunghan.** and 23 others.
Geological Society of America Bulletin. 2025. 137(3–4): 1267–1291.
doi: 10.1130/b37613.1.

Drill cores from the Antarctic continental shelf are essential for directly constraining changes in past Antarctic Ice Sheet extent. Here, we provide a sedimentary facies analysis of drill cores from International Ocean Discovery Program (IODP) Site U1521 in the Ross Sea, which reveals a unique, detailed snapshot of Antarctic Ice Sheet evolution between ca. 18 Ma and 13 Ma. We identify distinct depositional packages, each of which contains facies successions that are reflective of past baseline shifts in the presence or absence of marine-terminating ice sheets on the outermost Ross Sea continental shelf. The oldest depositional package (>18 Ma) contains massive diamictites stacked through aggradation and deposited in a deep, actively subsiding basin that restricted marine ice sheet expansion on the outer continental shelf. A slowdown in tectonic subsidence after 17.8 Ma led to the deposition of progradational massive diamictites with thin mudstone beds/laminae, as several large marine-based ice sheet advances expanded onto the mid- to outer continental shelf between 17.8 Ma and 17.4 Ma. Between 17.2 Ma and 15.95 Ma, packages of interbedded diamictite and diatom-rich mudstone were deposited during a phase of highly variable Antarctic Ice Sheet extent and volume. This included periods of Antarctic Ice Sheet advance near the outer shelf during the early Miocene Climate Optimum (MCO)—despite this being a wellknown period of peak global warmth between ca. 17.0 Ma and 14.6 Ma. Conversely, there were periods of peak warmth within the MCO during which diatom-rich mudstones with little to no ice-rafted debris were deposited, which indicates that the Antarctic Ice Sheet was greatly reduced in extent and had retreated to a smaller terrestrial-terminating ice sheet, most notably between 16.3 Ma and 15.95 Ma. Post-14.2 Ma, diamictites and diatomites contain unambiguous evidence of subglacial shearing in the core and provide the first direct, well-dated evidence of highly erosive marine ice sheets on the outermost continental shelf during the onset of the Middle Miocene Climate Transition

(MMCT; 14.2–13.6 Ma). Although global climate forcings and feedbacks influenced Antarctic Ice Sheet advances and retreats during the MCO and MMCT, we propose that this response was nonlinear and heavily influenced by regional feedbacks related to the shoaling of the continental shelf due to reduced subsidence, sediment infilling, and local sea-level changes that directly influenced oceanic influences on melting at the Antarctic Ice Sheet margin. Although intervals of diatom-rich muds and diatomite indicating open-marine interglacial conditions still occurred during (and following) the MMCT, repeated advances of marine-based ice sheets since that time have resulted in widespread erosion and overdeepening in the inner Ross Sea, which has greatly enhanced sensitivity to marine ice sheet instability since 14.2 Ma.

1-39

Geography, Physical; Geosciences, Multidisciplinary

Modelling the evolution of permafrost temperatures and active layer thickness in King George Island, Antarctica, since 1950

Pedro Baptista, Joana., Guapo Teles Vieira, Goncalo Brito., de Carvalho Soares Correia, Antonio Manuel., **Lee, Hyoungseok.** and Westermann, Sebastian.
Cryosphere. 2025. 19(9): 3459–3476.
doi: 10.5194/tc-19-3459-2025.

The dynamics of permafrost and the active layer is crucial for ecosystem processes in the ice-free areas of the Antarctic Peninsula, where a strong long-term warming trend with an increase of 3.4 °C in the mean annual air temperature since 1950 has been recorded. The consequences of this warming for past and future permafrost degradation are still not fully understood, mainly due to the sparse spatial coverage and limited time span of borehole data, which have only been available since the mid- to late 2000s. This motivated the application of the CryoGrid community model (CCM) for modelling ground temperatures at the bedrock drilled King Sejong Station (KSS) borehole on Barton Peninsula, King George Island. The objective was to assess the model’s quality and potential for applicability in other ice-free areas of the Antarctic Peninsula, aiming to improve the understanding of the recent evolution of permafrost temperature and active layer thickness and reconstitute the past evolution since 1950. ERA5 reanalysis

data underestimated air temperature, strongly impacting the rate and intensity of ground warming during the thawing seasons. Linear regression with in situ observations was used to correct the ERA5 forcing. The results of a short-term simulation from 2020–2022 evaluated against observations show that the model successfully represents the conditions at the KSS borehole. Down to 6 m depth, correlations above 0.9 were obtained, while below 6 m, the correlations were above 0.8. The mean absolute error ranged from 0.1 to 0.7 °C. Active layer depths of 2.9 to 3.1 m showed an overestimation of ca. 0.4 m. The long-term simulation of permafrost and active layer temperatures from 1950 to 2022 using ERA5 data showed a ground warming trend at 20 m of 0.25 °C per decade accompanied by an increase in the active layer thickness from 1.5 m in 1950 to 3.5 m in 2022. From 2015, the warming rate increased significantly to 0.9 °C per decade.

1-40

Green & Sustainable Science & Technology; Energy & Fuels

Modifying carbon feedback by transforming arctic soil into biochar

Lee, Taewoo., Cha, Hoyeon., Kim, Jee Young., Choi, Hyeseung., Lee, Jaewon., Yun, Seunggwan., **Lee, Yoo Kyung.**, Lee, Jechan., **Jung, Ji Young.** and Kwon, Eilhann E.
Renewable & Sustainable Energy Reviews. 2025. 216.
doi: 10.1016/j.rser.2025.115712.

The escalation of global temperatures has heightened uncertainties in the Arctic, particularly regarding the potential release of greenhouse gases, such as carbon dioxide, through permafrost thawing. This phenomenon is primarily driven by positive carbon feedback, leading to 3.3 times faster Arctic warming rate than the global average. To address this challenge, this study proposes a proactive strategy for substituting Arctic underground soil with biochar to mitigate carbon dioxide emissions. Particularly, utilising carbon dioxide (CO₂) as a reactive feedstock to the pyrolysis system opens up opportunities to produce the functionalized biochar for adsorbing CO₂, simultaneously enhancing energy recovery from other pyrogenic products, such as syngas and biocrude. Moreover, a comprehensive techno-economic analysis allowed to determine optimized pyrolytic conditions for biochar production. Despite the necessity of high reaction temperatures, the utilisation of carbon dioxide demonstrated

superior performance in terms of energy recovery and carbon dioxide mitigation. The biochars produced represent a potential of offsetting CO₂ emission, with an estimated decrease rate of 51.6 Gt CO₂ yr^{−1} by 2100 over the next 75 years. Therefore, this study introduces a strategic approach to mitigate positive carbon feedback and slow global climate change by incorporating CO₂ for the biochar production.

keywords:

Global warming; Positive carbon feedback; Arctic soil; Carbon dioxide; Biochar

1-41

Environmental Sciences; Public, Environmental & Occupational Health

Molecular insights into the warming-induced alterations of water-extractable organic matter (WEOM) in soil: Depth-dependent responses in Arctic terrestrial ecosystem

Kim, Min Sung., Kim, You Jin., **Jeong, Sujeong.**, Nam, Sungjin., Kwon, Min Jung., Wagner, Johann., Hik, David., **Lee, Joohan.**, Choi, Mira., **Jung, Ji Young.** and Jang, Kyoung-Soon.
Environmental Research. 2025. 285.
doi: 10.1016/j.envres.2025.122320.

Arctic warming is accelerating at a rate approximately four times faster than the global average, exerting profound effects on soil organic matter and microbial activity, particularly in permafrost regions rich in soil carbon stocks. This study investigates the molecular composition of water-extractable organic matter (WEOM) in response to a 7-year period of warming via open-top chambers across different soil layers in a dry Arctic tundra ecosystem. We focused on elucidating the depth-dependent responses of WEOM to warming, emphasizing compositional shifts and proportional changes in WEOM constituents using ultra-high-resolution Fourier transform ion cyclotron resonance mass spectrometry (FT-ICR MS). Our results indicate that the organic layer exhibited minimal changes in soil properties and WEOM composition in response to warming. In contrast, the mineral layer demonstrated significant alterations with warming, including increased total dissolved nitrogen content, enhanced biological activity, and shifts in WEOM molecular composition. Particularly, the warming treatment led to an increase in the abundance of highly unsaturated and phenolic compounds (HUP) and peptidelike compounds in the mineral layer,

reflecting enhanced microbial utilization of WEOM. This study underscores the critical importance of considering soil depth and layer when assessing the ecological impacts of climate warming, particularly in Arctic regions where microbial activities remain limited. These results suggest that warming-induced changes in the mineral layer may reflect stimulation of microbial communities by belowground processes, such as rhizosphere expansion or organic input from upper soil horizons, although these mechanisms remain to be directly confirmed. These results provide valuable insights into the mechanisms driving WEOM transformations under warming conditions, contributing to a more comprehensive understanding and prediction of biogeochemical processes occurring in a warming Arctic.

keywords:
Arctic warming; WEOM; Soil layer; Nitrogen cycling; FT-ICR MS

1-42

Chemistry, Multidisciplinary

Molecular Mechanisms of Gas-Ice Interfacial Transport: Size- and Charge-Dependent Fractionation during Bubble Close-off

Yi, Yoo Soo. and Han, Yeongcheol.
Acs Omega. 2025. 10(45): 54700–54709.
doi: 10.1021/acsomega.5c08111.

Gas-ice interfacial transport phenomena are essential across diverse cryogenic environments, ranging from gas fractionation in polar glaciers to the preservation of cosmogenic noble gases on icy celestial bodies. Bubble close-off in polar glaciers is a compelling example of the complex gas-ice interactions that challenge the interpretation of paleoclimate records preserved in ice cores. While previous studies have provided valuable insights, the molecular mechanisms governing fractionation, especially those involving both geometric and electronic characteristics, remain incompletely understood. Here, using density functional theory (DFT) calculations, we determine effective permeation energy barriers (E_p) for noble gases (He, Ne, Ar, Kr, and Xe) and molecular gases (N_2 , O_2 , and CO_2) through a model ice layer. Our results reveal that noble gases largely follow a size-dependent trend, whereas molecular gases deviate from such a simple relationship due to more complex gas-ice interactions resulting from their anisotropic charge distribution. The exponential dependence of

permeation rates on E_p accounts for the observed nonlinear depletion phenomenon. He and Ne, with their smaller sizes and weaker surface adsorption, exhibit higher permeation rates and rapid depletion from closed-off bubbles. Conversely, larger noble gases and molecular gases are preferentially retained due to increased energy barriers. Notably, molecular gases show significantly lower permeation rates than Ne despite comparable effective cross-sectional sizes, owing to stronger adsorption affinity. Chemical hardness, a descriptor reflecting electronic properties, helps reconcile the fractionation patterns observed for both gas types, indicating that interfacial interactions, not molecular size alone, govern transport through ice layers. These findings provide insights into gas preservation in diverse cryogenic environments, which is essential for the fidelity of paleoclimate reconstruction and the rational design of materials for selective transport. Discrepancies with field observations underscore the role of structural heterogeneities, such as grain boundaries, suggesting that bubble close-off fractionation involves additional pathways beyond idealized lattice permeation.

1-43

Geography, Physical; Geosciences, Multidisciplinary

Monitoring shear-zone weakening in East Antarctic outlet glaciers through differential InSAR measurements

Wild, Christian T., Drews, Reinhard., Neckel, Niklas., Lee, Joohan., Kim, Sihyung., Han, Hyangsun., Lee, Won Sang. and 4 others.
Cryosphere. 2025. 19(10): 4533–4554.
doi: 10.5194/tc-19-4533-2025.

The stability of the Antarctic Ice Sheet depends on ice flux into the ocean through major outlet glaciers, which is resisted by shear stresses in the lateral shear margins, both on grounded ice and on floating ice shelves. Within the tidal-flexure zone, where the ice sheet transitions from fully grounded to freely floating, ocean tides lead to a characteristic flexural pattern, which can be detected by radar satellites in differential interferograms. Here, we investigate how spatially heterogeneous elastic ice-shelf properties in the shear zones affect tidal flexure and whether a corresponding signature can be detected in satellite observations. We use the Young’s

modulus (which, among others, depends on ice temperature and/or ice-crystal orientation fabric and damage) as a bulk tuning variable for changing ice stiffness across shear zones and show that this leads to centimeter-scale deviations in vertical displacement, compared with a homogeneous elastic flexure model. Using the tidal-flexure zone of Priestley Glacier as an example, we compare homogeneous and heterogeneous flexure-model predictions with observations from 31 differential interferograms. After adjusting the local tide model and validating it with in situ GPS data, we find that a 5-fold reduction of the Young’s modulus in the shear zone, i.e., an effective shear-zone weakening, reduces the root-mean-square error of predicted and observed vertical displacement by 33 % within the central part of the ice shelf. This suggests that satellite interferometry can detect changing ice stiffness across shear zones, with the potential to inform ice-flow models about the often unknown spatial variability in ice-shelf properties along the grounding zone.

1-44

Engineering, Electrical & Electronic; Geography, Physical; Remote Sensing; Imaging Science & Photographic Technology

Monitoring Subglacial Lake Activity in the David Glacier Region, East Antarctica, Using a DInSAR Displacement Integration Approach

Kim, Taewook., Han, Hyangsun., Lee, Hoonyol. and Ju, Hyeontae.
IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing. 2025. 18: 22175–22192.
doi: 10.1109/jstars.2025.3601588.

Subglacial lakes significantly influence ice sheet dynamics, necessitating precise monitoring of their activity. This study presents a novel approach that integrates differential interferometric synthetic aperture radar (DInSAR) displacements from Sentinel-1 data to estimate high-resolution time series of ice sheet surface elevation changes associated with subglacial lake activity. Applying this approach to the David Glacier region in East Antarctica from 2016 to 2023, we identified and analyzed the activity of Lake David(2) and newly identified subglacial lakes, David(2-1) and David(A). The ice sheet elevation changes derived from the DInSAR displacement integration showed strong agreement with Ice, Cloud, and land Elevation Satellite-2 observations and allowed

for detailed monitoring of subglacial lake activity. The ice sheet surface above Lake David(A) showed a marked rise in early 2016 due to lake filling, followed by a stable period until 2020. A rapid surface decline occurred in late 2020 due to drainage. Since 2021, the surface decline has continued at slower rates, indicating gradual water level lowering. Lake David(2-1) filled by early 2021 and subsequently exhibited alternating drainage and filling. The ice sheet surface above Lake David(2) exhibited sustained uplift until 2020, attributed to continuous water filling, and then transitioned to a phase of drainage. Hydraulic potential-derived basal water pathways suggested that Lake David(A) was likely supplied by undetected inflows, while Lake David(2) primarily received water from a southern pathway rather than from Lake David(2-1). This study demonstrates the effectiveness of time-series DInSAR for subglacial lake monitoring, overcoming limitations of altimetry-only observations and providing insights into subglacial hydrology and ice sheet dynamics.

keywords:
Lakes; Ice sheets; Ice; Sea surface; Synthetic aperture radar; Surface topography; Interferometry; Monitoring; Filling; Antarctica; David Glacier; differential interferometric synthetic aperture radar (DInSAR); ice sheet surface elevation change; subglacial lake

1-45

Geosciences, Multidisciplinary

New Catalog of Thwaites Glacier Subglacial Lakes and Their Activity Revealed by CryoSat-2 Altimetry

Kim, Byeong-Hoon., Lee, Choon-Ki., Seo, Ki-Weon., Lee, Won Sang. and Park, Jeong-Won.
Journal of Geophysical Research–Earth Surface. 2025. 130(6).
doi: 10.1029/2023jf007602.

Previously, the existence of seven active subglacial lakes was reported beneath Thwaites Glacier, one of West Antarctica’s largest glaciers, predicted to significantly impact future sea level rise. In this study, we re-evaluate the CryoSat-2 satellite radar altimeter data from 2010 to 2022 and identify 27 subglacial lakes that were active during 2013–2014 and 2016–2018, including those previously observed. Our new observations reveal three lakes located downstream of the lakes identified previously that

appear to drain 3 months prior to the drainage of upstream lakes in 2013. Despite being over 100 km apart, the observed lakes (from the farthest upstream to downstream) exhibited synchronized behaviors. The timing of lake activities shows a complex activity propagation pattern, featuring both upward and downward transmission, contrasting with the simpler, one-directional flows observed in previous studies. While lake activities correlate with abrupt changes in ice speed near the grounding line, their impacts are limited, regardless of the total amount of drained water.

keywords:
subglacial lake; Antarctica; Thwaites glacier

1-46

Geosciences, Multidisciplinary; Meteorology & Atmospheric Sciences

Optimal localization radius of data assimilation for Arctic sea ice initialization using CICE5/DART

Kim, Ji-Soo., Chung, Inchaе., **Noh, Young-Chan., Choi, Yonghan., Kim, Joo-Hong.** and 2 others.
Geoscience Letters. 2025. 12(1).
doi: 10.1186/s40562-025-00440-3.

In data assimilation (DA), localization, which adjusts the influence of observations on model state vectors, is an essential process for improving initial conditions. Given that the localization radius varies depending on the model and observation, sensitivity tests were conducted to identify the optimal localization radius for assimilating satellite-derived sea ice concentration and sea ice thickness into Los Alamos Sea Ice Model version 5 (CICE5) using Data Assimilation Research Testbed (DART). In all experiments, the updated Arctic sea ice initial conditions were generally improved across Pan-Arctic regions and time periods. Based on the sensitivity tests, the optimal localization radius for univariate DA was approximately 0.05 radians which is the default value in CICE5/DART. However, for multivariate DA, it was around 0.02 radians. This implies that the optimal localization condition for assimilation may vary depending on whether univariate or multivariate observations are being assimilated.

keywords:
Arctic sea ice; Sea ice concentration; Sea ice thickness; Data assimilation; Localization radius

1-47

Environmental Sciences; Geosciences, Multidisciplinary; Meteorology & Atmospheric Sciences

Origin of the 1458/59 CE volcanic eruption revealed through analysis of glass shards in the firn core from Antarctic Vostok station

Ro, Seokhyun., Hur, Soon Do., Ekaykin, Alexey., **Han, Yeongcheol.,** Ro, Chul-Un., **Hong, Sang-Bum., Lee, Mi Jung., Chang, Chaewon., Lee, Seungmi., Moon, Jangil., Jung, Hyejin.,** Veres, Arina., **Lee, Ahhyung.** and Hong, Sungmin.
Communications Earth & Environment. 2025. 6(1).
doi: 10.1038/s43247-025-02797-x.

The 1458/59 CE volcanic event, among the largest in the last millennium, is primarily attributed to the Kuwae volcano in Vanuatu. However, a recent study suggests the Reclus volcano in southern Patagonia, Chile, as an alternative source. Here, we assess the hypothesis by examining unpolished, micron-sized glass shards from the 1458/59 CE cryptotephra in the Antarctic Vostok Station firn core. Results reveal a bimodal composition of dacitic and rhyolitic shards, linked to Kuwae and Reclus, respectively. Antarctic ice core records also exhibit a two-stage pattern of ash deposition: coarse ash from nearby volcanoes followed by finer ash transported over long distances, implying concurrent eruptions. Nevertheless, discrepancies in composition between observed rhyolitic shards and existing Reclus data, combined with no recorded Reclus activity in the 1450 s, suggests the possibility of an undocumented extratropical rhyolitic source. This study underscores the value of glass shard analysis in identifying the origins of volcanic eruptions.

1-48

Geography, Physical; Geosciences, Multidisciplinary; Paleontology

Paleoceanographic condition changes in the Eastern Bransfield Basin, Antarctic Peninsula, since the late glacial interval and its implications

Kim, Sunghan., Bak, Young-Suk., Yoo, Kyu-Cheul., **Lee, Min Kyung., Lee, Jae Il.,** Kim, Sookwan., **Park, Jinku., Kim, So-Young., Moon, Heung Soo., Kang, Myung-Il.** and **Kim, Hyo Jin.**
Palaeogeography Palaeoclimatology Palaeoecology. 2025. 669.
doi: 10.1016/j.palaeo.2025.112934.

Antarctic Peninsula is the most northerly area in the Antarctica, thus it is vulnerable to warming climate. Although it is well known that relatively warm water mass input onto the Antarctic shelf region facilitates ice shelf retreat, when and how the water mass exchange between the deep Southern Ocean and the Antarctic shelf regions is not well known in ice proximal areas due to sea ice dynamics on the continental shelf region. Here, we document the diatom assemblage record of a sediment core with high sedimentation rates since the late glacial interval from 34.6 ka to address surface environmental changes in the Eastern Bransfield Basin (EBB). We found that the EBB was covered by extensive sea ice showing millennial-scale variations during the late glacial interval. The sea ice started to decrease during the deglacial interval (19–11 ka) with slight increases of open ocean influence. In addition, meltwater input was significant during 14.7–11.3 ka which corresponds to Antarctic Ice Sheet Discharge events reported in the Scotia Sea including Meltwater pulse 1A and 1B. During the Holocene after 9 ka, relatively warm water mass input distinctively increased into the EBB contemporaneous with a remarkable decrease in sea ice influence indicating the strong relationship between sea ice and warm water mass input. In addition, meltwater input at 9 ka was also distinctive in the EBB, but there was no corresponding Antarctic Ice Sheet Discharge event in the Scotia Sea. Our results show how well surface environmental changes in the EBB correspond to the global climate change and the regional climatic characteristics at the same time.

keywords:
Diatom; Bransfield Basin; Meltwater pulse; Antarctic Peninsula; The late glacial interval

1-49

Geography, Physical; Geosciences, Multidisciplinary; Paleontology

Paleoceanographic responses to sea level variability in the East Sea since the last glacial period: Multi-proxy approach

Jang, Kwangchul., Bayon, Germain., **Han, Yeongcheol., Ahn, Youngkyu., Joe, Young Jin., Son, Yeong Ju., Lee, Seungmi.,** Jin, Jae Hwa., Byun, Eunji. and **Nam, Seung-Il.**
Palaeogeography Palaeoclimatology Palaeoecology. 2025. 661.
doi: 10.1016/j.palaeo.2024.112706.

The oceanographic conditions in the East Sea have significantly changed over glacial–interglacial cycles, but the underlying mechanisms remain poorly understood due to limited data. We present multi-proxy records from three sediment cores along the western margin of the East Sea to reconstruct past oceanic conditions since Marine Isotope Stage (MIS) 5. Our results reveal contrasting conditions between glacial and interglacial periods. First, detrital Nd isotopes provide evidence for provenance changes suggesting a reduced contribution of seawater inflow from the Tsushima Warm Current compared to the local fluvial influx from Japanese islands during the last glacial period, most likely linked to sea level drop. As a result, the East Sea likely experienced surface water freshening, particularly during MIS 2, when seawater exchange through the Korea/Tsushima Strait was (almost) entirely restricted, as evidenced by decreasing oxygen isotope ratios in planktonic foraminifers. Authigenic Nd isotopes suggest that this freshening caused strong water column stratification, limiting vertical mixing below ~800 m. Consequently, bottom waters likely became oxygen-depleted, as indicated by decreases in total organic carbon to total sulfur contents and cerium anomalies and an increase in authigenic molybdenum concentrations. The reduced horizontal and vertical water mixing also possibly limited nutrient supply during the last glacial period, resulting in diminished primary productivity. This study emphasizes the distinctive response of the East Sea’s oceanographic conditions to climate-driven sea level fluctuations and highlights its potential contribution to the global ocean carbon reservoir during glacial periods.

keywords:
Ocean anoxia; Ocean freshening; Neodymium isotopes; Rare earth elements; Authigenic; Last glacial maximum

1-50

Environmental Sciences; Geosciences, Multidisciplinary; Meteorology & Atmospheric Sciences

Paleoclimate proxy records suggest reduced tropical Pacific zonal asymmetry under sustained global warming

Chung, Eui-Seok., Kim, Seong-Joong., Rodgers, Keith B., **Jun, Sang-Yoon., Kim, Joo-Hong.** and 2 others.
Communications Earth & Environment. 2025. 6(1).
doi: 10.1038/s43247-025-02039-0.

Pronounced model–observation discrepancies in the changes of tropical Pacific zonal sea surface temperature gradient during the satellite era imply systematic model deficiencies. However, the relatively short high–quality instrumental record hampers robustly determining the response of tropical Pacific sea surface temperature to greenhouse gas increases. By adopting paleoclimate proxy records along with a series of climate model simulations, here we show that the zonal gradient is likely to decrease under sustained strong forcing. Paleoclimate proxy records indicate an overall increase of the zonal gradient over time, which has been accompanied by global–mean cooling associated with decreasing carbon dioxide concentrations. Model simulations are found to broadly reproduce the distinct contrast between warmer high carbon dioxide climates and the opposite climates, albeit with large inter–model discrepancy. The qualitative agreement among paleoclimate proxy records and modeled representations therefore lends some important credence to the sign of model–projected future tropical Pacific mean state change.

1-51

Environmental Sciences; Meteor ology & Atmospheric Sciences

Performance Evaluation of PM_{2.5} Forecasting Using SARIMAX and LSTM in the Korean Peninsula

Lee, Chae–Yeon. and 5 others.
Atmosphere. 2025. 16(5).
doi: 10.3390/atmos16050524.

Air pollution, particularly fine particulate matter (PM_{2.5}), poses significant environmental and public health challenges in South Korea. The National Institute of Environmental Research (NIER) currently relies on numerical models such as the Community Multiscale Air Quality (CMAQ) model for PM_{2.5} forecasting. However, these models exhibit inherent uncertainties due to limitations in emission inventories, meteorological inputs, and model frameworks. To address these challenges, this study evaluates and compares the forecasting performance of two alternative models: Long Short–Term Memory (LSTM), a deep learning model, and Seasonal Auto Regressive Integrated Moving Average with Exogenous Variables (SARIMAX), a statistical model. The performance evaluation was focused on Seoul, South Korea, and took place over different forecast

lead times (D00–D02). The results indicate that for short–term forecasts (D00), SARIMAX outperformed LSTM in all statistical metrics, particularly in detecting high PM_{2.5} concentrations, with a 19.43% higher Probability of Detection (POD). However, SARIMAX exhibited a sharp performance decline in extended forecasts (D01–D02). In contrast, LSTM demonstrated relatively stable accuracy over longer lead times, effectively capturing complex PM_{2.5} concentration patterns, particularly during high–concentration episodes. These findings highlight the strengths and limitations of statistical and deep learning models. While SARIMAX excels in short–term forecasting with limited training data, LSTM proves advantageous for long–term forecasting, benefiting from its ability to learn complex temporal patterns from historical data. The results suggest that an integrated air quality forecasting system combining numerical, statistical, and machine learning approaches could enhance PM_{2.5} forecasting accuracy.

keywords:
PM_{2.5} forecasting; LSTM; SARIMAX; air quality prediction; deep learning; statistical modeling

1-52

Environmental Sciences; Marine & Freshwater Biology; Toxicology

Quantifying dimethylsulfoniopropionate lyase activity in marine environments using selected ion flow tube mass spectrometry

Park, Ki–Tae., Yoon, Young Jun. and Lee, Kitack.
Marine Environmental Research. 2025. 208.
doi: 10.1016/j.marenvres.2025.107125.

The global sulfur cycle is largely influenced by the production of dimethyl sulfide (DMS), which is primarily generated through the enzymatic cleavage of algal dimethylsulfoniopropionate (DMSP). This study presents an efficient and simplified method for analyzing DMSP lyase activity (DLA) by measuring the conversion efficiency of DMSP to DMS using selected ion flow tube mass spectrometry (SIFT–MS) coupled with a dissolved gas extraction device. Unlike conventional methods, which involve multiple steps such as trapping, desorption, and chromatographic separation, the proposed method consists of two streamlined steps: (1) Introduction of excess DMSP substrate into the sample vial, followed by continuous measurement of DMS evolution via SIFT–MS; (2) recording the DMS response at 3–s intervals and calculating the DMS

production rate by dividing the integrated DMS mass over time intervals. The high–frequency detection of trace–level DMS enhances the accuracy of release rate measurements and aids in optimizing the DMSP substrate concentration. The performance of the proposed method was evaluated using cultured phytoplankton and natural seawater samples, achieving an analytical precision less than 10 % and a total analysis time of under 10 min, substantially faster than traditional gas chromatography–based techniques. This method provides a robust tool for investigating the dynamics of DMS–related processes in marine environments.

keywords:
Dimethyl sulfide (DMS); Dimethylsulfoniopropionate (DMSP); Dimethylsulfoniopropionate lyase activity (DLA); Phytoplankton; Selected ion flow tube mass spectrometry (SIFT–MS); Marine sulfur cycle

1-53

Environmental Sciences; Geosciences, Multidisciplinary; Meteorology & Atmospheric Sciences

Recent asymmetric tropical ocean warming has altered regional propagation of Madden–Julian Oscillation

Kim, Hye–Ryeom., Ha, Kyung–Ja., Roxy, Mathew Koll., Chung, Eui–Seok. and 3 others.
Communications Earth & Environment. 2025. 6(1).
doi: 10.1038/s43247–025–02652–z.

Tropical sea surface temperature warming displays distinct regional patterns, but its influence on Madden–Julian Oscillation propagation remains unclear. Here we investigate how a shift toward La Niña–like conditions around 1999 has affected Madden–Julian Oscillation propagation by comparing two periods: 1979–1998 and 2003–2022. Using satellite observations and reanalysis data, we show that propagation accelerated over the Indian Ocean and the Maritime Continent but slowed over the western Pacific in the later period. These contrasting responses are linked to changes in sea surface temperature patterns and associated atmospheric conditions. Over the Indian Ocean, enhanced low–level horizontal moisture gradients and increased upper–tropospheric stability facilitate propagation, while weakened

moisture gradient and suppressed convection hinder it over the western Pacific. Despite complex terrain and atmospheric interactions over the Maritime Continent, background changes still favor enhanced propagation. These findings highlight the sensitivity of Madden–Julian Oscillation behavior to regional ocean–atmospheric conditions, with implications for improving subseasonal prediction.

1-54

Geosciences, Multidisciplinary

Recording of paleoenvironmental changes using diatom assemblages from the Amundsen Sea, Antarctica

Bak, young–suk., Kim, Sunghan., Yoo, Kyu–Cheul., Lee, Min Kyung. and **Ha, Sangbeom.**
Journal of the Geological Society of Korea. 2025. 61(3): 263–270.
doi: 10.14770/jgsk.2025.020.

To reconstruct past ice shelf behavior, diatoms were analyzed from core sediments obtained near the Getz ‘A’ Ice Shelf in the Amundsen Sea embayment of Antarctica. A total of 50 diatom species representing 22 genera were identified from AM22–GC10B, with abundances varying from 0.5 to 8.3 × 10⁷/g. By examining the patterns of sea ice, open ocean species, and magnetic susceptibility (MS) values, three assemblage zones were established. These zones reveal significant changes in the paleoenvironment: Diatom assemblage zone I corresponds to subglacial condition, characterized by low diatoms and high magnetic susceptibility values. Diatom assemblage zone II represents the glacialmarine, showing a shift from subglacial to seasonal open marine conditions, with increasing diatom abundance and decreasing magnetic susceptibility. Diatom assemblage zone III indicates a seasonal open marine period, characterized by high diatom abundance, increasing *Chaetoceros* resting spores, decreasing sea ice species, and increasing open ocean species.

keywords:
Antarctica; Amundsen Sea embayment; diatom assemblage; sea ice species; open ocean species

1-55

Review of Recent Polar Climate Change and Its Impact

Kim, Seong-Joong. and Chung, Eui-Seok.
The Korean Journal of Quaternary Research. 2025. 35(2): 1–15.
doi: 10.22658/koq.2025.35.2.001

Since the Industrial Revolution, the global average temperature has risen by 1.09°C, which is an unprecedented rate over the past several millenia. Arctic warming is occurring at a faster rate than the global average by three to four times. This rapid warming in the Arctic compared to the global average is called Arctic amplification. Arctic warming is contributing to the rapid decline of sea ice and glaciers. Delayed sea ice formation in autumn and winter strengthens high and low pressure systems in mid-latitudes as well as weakening the polar vortex, that intensifies cold and heat waves in mid-latitudes. In contrast to the Arctic, Antarctica exhibits distinct temperature changes. West Antarctica had warmed rapidly and experienced a decline in sea ice and ice sheets by around 2012, whereas East Antarctica had experienced a decline in temperature and an increase in sea ice and land ice. The decrease in temperature and increase in sea ice in Antarctica are linked to declining stratospheric ozone concentrations and appear to have resulted in part from low-latitude effects. However, since the early 2010s, temperatures have increased in all areas, and sea ice has decreased, indicating a possible shift in the Antarctic climate change regime. This study examines the causes of the different responses of the Arctic and Antarctic to increasing greenhouse gases.

keywords:
Arctic amplification; Arctic sea ice reduction; Midlatitude extreme weather; Antarctic climate asymmetry; Antarctic sea ice increase

1-56 Environmental Sciences; Meteorology & Atmospheric Sciences

Role of a key microphysical factor in mixed-phase stratocumulus clouds and their interactions with aerosols

Lee, Seoung Soo., Jung, Chang Hoon., Choi, Jinho., Yoon, Young Jun. and 5 others.
Atmospheric Chemistry and Physics. 2025. 25(2): 705–726.
doi: 10.5194/acp-25-705-2025.

This study examines the ratio of ice crystal number concentration (ICNC) to cloud droplet number concentration (CDNC), that is ICNC / CDNC, in mixed-phase stratocumulus clouds. This examination is performed using a large-eddy simulation (LES) framework and is one of the efforts toward a more general understanding of mechanisms controlling cloud development and aerosol-cloud interactions, as well as the impacts of ice processes on them in mixed-phase stratocumulus clouds. For the examination, this study compares a case of polar mixed-phase stratocumulus clouds to one of midlatitude mixed-phase stratocumulus clouds with weak precipitation. It is found that ICNC / CDNC plays a critical role in causing differences in cloud development with respect to the relative proportion of liquid and ice mass between the cases by affecting in-cloud latent-heat processes. Note that this proportion has an important implication for cloud radiative properties and, thus, for climate. It is also found that ICNC / CDNC plays a critical role in causing differences in the interactions between clouds and aerosols and in the impacts of ice processes on clouds and their interactions with aerosols between the cases by affecting in-cloud latent-heat processes. Findings of this study suggest that ICNC / CDNC can be a simplified general factor that contributes to a more general understanding and parameterization of mixed-phase clouds, their interactions with aerosols and the roles of ice processes within them.

1-57 Meteorology & Atmospheric Sciences

Sea Ice Initialization and Its Impact on Winter Seasonal Prediction Skill over the Northern Hemisphere in Coupled Forecast System

Sim, Ji-Han., Kim, Baek-Min., Lee, Jeong-Gil., Lim, Young-Kwon., Kim, Joo-Hong. and Kim, Ju Heon.
Journal of Climate. 2025. 38(16): 3989–4001.
doi: 10.1175/jcli-d-24-0524.1.

Recent advancements in coupled models and Arctic sea ice satellite observations have prompted research on sea ice initialization. To assess its impact on winter surface air temperature (SAT) seasonal prediction skill, three initialization methods based on nudging are evaluated using the Community Earth System Model, version 2 (CESM2). The methods include 1) generating ocean/sea ice initial conditions (ICs) solely from atmospheric forcing (Ex_{ctrl}), 2) building upon Ex_{ctrl} by directly nudging sea ice concentration to observation and thickness to reanalysis data to produce improved ICs ($Ex_{icenudge}$), and 3) further enhancing $Ex_{icenudge}$ by applying additional atmospheric forcing to adjust model balance ($Ex_{balance}$). The retrospective predictions are initialized on 21 October for 24 years from 1993 to 2016. The anomaly correlation coefficients from the retrospective predictions are 0.27, 0.15, and 0.45 for northern Eurasia and 0.23, 0.27, and 0.39 for southern Eurasia in Ex_{ctrl} , $Ex_{icenudge}$, and $Ex_{balance}$, respectively. The $Ex_{balance}$ demonstrates the highest prediction skill, with notable improvements in areas associated with the warm Arctic-cold Eurasia pattern. The $Ex_{balance}$ accurately simulates the SAT distribution, which is characterized by the Barents Oscillation, and effectively captures the polar vortex, a crucial factor in determining Arctic temperatures. The enhanced prediction skill in $Ex_{balance}$ can be attributed to improved SST bias of ICs and better-balanced sea ice ICs with the atmosphere, significantly reducing the strong warm bias within the Arctic Ocean compared to $Ex_{icenudge}$. Altogether, this study highlights that when model bias is substantial, maintaining model balance is more critical than assimilating sea ice conditions that closely match observations for improving seasonal prediction skill.

keywords:
Hindcasts; Seasonal forecasting; Coupled models; Data assimilation; Model initialization; Seasonal variability

1-58 Engineering, Electrical & Electronic; Geography, Physical; Remote Sensing; Imaging Science & Photographic Technology

Sea-Ice Surface Types Characterization and SAR Volume Backscattering Properties in Response to Sea States Interactions Using Structural Feature Fusion

Shahrezaei, Iman Heidarpour. and Kim, Hyun-Cheol.
IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing. 2025. 18: 7967–7981.
doi: 10.1109/jstars.2025.3548597.

Despite extensive research in polar remote sensing, there is still no consensus on how sea-ice evolves in response to interactions with ocean waves, nor is there agreement on the most effective way to characterize it based on fluctuations in height profile, both of which compromise interpretations of its texture properties when observed by synthetic aperture radar (SAR). This study aims to address these knowledge gaps by investigating the sea-ice modeling, marginal ice zone (MIZ) categorization and identifying an optimal approach to extract its freeboard profile and relevant backscattering properties under varying sea state conditions. To accomplish this, a numerical approach for modeling random polar media (RPM) is proposed, benefiting from transform-domain fusion method decompositions in conjunction with a convolutional neural network to jointly reconstruct a reference MIZ model in response to wind waves. To ensure consistency in surface structure, the fusion scheme incorporates a point-wise processing principle technique. The reconstructed reference sea-ice model is then subjected to an inverse problem solution analysis to generate the SAR volume backscattering dataset. The simulation results show that the entire routine, encompassing RPM modeling, MIZ characterization, structural fusion, and SAR raw data generation, yields promising results in the realm of sea-ice remote sensing. It reduces dependence on empirical methods, which typically necessitate polar field experiments that are limited by access constraints, or incorporate nonuniform and time-varying media characteristics into large-scale theoretical observation.

keywords:
Sea surface; Sea ice; Sea state; Synthetic aperture radar; Media; Backscatter; Surface reconstruction; Surface waves; Remote sensing; Numerical models; Random polar media (RPM); raw data; sea state; synthetic aperture radar (SAR); transform-domain fusion; volume backscattering

1-59 Geology; Geosciences, Multidisciplinary

Seasonal variability of isotopes and chemistry in a coastal firn core from the Amundsen Sea, West Antarctica

Shin, Jinhwa., Han, Yeongcheol., Hong, Sang-Bum., Jung, Hyejin., Chang, Chaewon., Moon, Jangil., Kim, Minjeong., Bong, Hayoung., Yoshimura, Kei., Lee,

Jaeseok., **Lee, Seungmi., Ro, Seokhyun., Kim, Songyi.** and **Hur, Soon Do.**
New Zealand Journal of Geology and Geophysics. 2025. 68(5): 1207–1218.
doi: 10.1080/00288306.2025.2510383.

The West Antarctic Ice Sheet (WAIS) is undergoing significant ice loss, causing global sea level rise and posing a critical threat to coastal communities worldwide (Shepherd et al. 2018; Rignot et al. 2019). We analyzed stable isotopes, major ions, and hydrogen peroxide (H₂O₂) in a 10.11 m shallow ice core from Moore Dome, West Antarctica, to provide a basis for future deep ice-core studies. Seasonal peaks in H₂O₂, methanesulfonic acid (MSA, CH₃SO₃⁻), and non-sea-salt sulphate (nss-SO₄²⁻) served as annual layer markers, yielding a chronology from austral spring/summer 2012 to 2016 and a mean accumulation rate of 1.25 m w.e. yr⁻¹. The δD - $\delta^{18}O$ slope of 7.93 closely matches the Global Meteoric Water Line (GMWL, slope=8; Dansgaard 1964), indicating minimal post-depositional alteration. Comparisons with IsoGSM model output confirm that $\delta^{18}O$ reliably reflects regional climate variability. Variations in sea-salt ions (Na⁺, Cl⁻, K⁺, Mg²⁺, Ca²⁺) and biogenic sulphate (MSA, nss-SO₄²⁻) reflect seasonal marine influences, including winter sea spray and summer phytoplankton blooms. These findings highlight Moore Dome’s capacity to preserve high-resolution climate signals and demonstrate the value of integrating observational records with models to improve understanding of long-term WAIS instability.

keywords:
Antarctica; paleoclimate; ice cores; major ions; water stable isotopes

1-60 **Ecology; Geosciences, Multidisciplinary**

Sedimentary organic carbon dynamics in a glaciated Arctic fjord: tracing contributions of terrestrial and marine sources in the context of Atlantification over recent centuries

Kim, Dahae., Kim, Jung-Hyun., Ahn, Youngkyu., Forwick, Matthias. and **Nam, Seung-II.**
Biogeosciences. 2025. 22(16): 4087–4105.
doi: 10.5194/bg-22-4087-2025.

In this study, we investigated sedimentary organic carbon (OC) dynamics in Kongsfjorden, Svalbard, using three multicores collected during the HH22 and HH23 cruises aboard the RV Helmer Hanssen in 2022 and 2023. We assessed the relative contributions of petrogenic, soil-derived, plant-derived, and marine OC by applying a four-source apportionment approach based on $\Delta^{14}C_{org}$, $\delta^{13}C_{org}$, and lignin parameters, including the (Ad / Al)_v ratio and lignin phenol concentrations, with Monte Carlo (MC) analysis. Age-depth models based on 210Pb and 226Ra data were used to evaluate temporal variations in the accumulation rates (ARs) of sedimentary OC. Our results revealed a marked increase in marine OC ARs over the past decades, closely linked to enhanced Atlantic Water (AW) inflow. The increasing AW influence in Arctic fjords observed in our record points to the potential for continued Atlantification under Arctic warming, as retreating sea ice and glaciers lower barriers to AW intrusion, enabling deeper and more persistent inflow. By putting this recent AW trend into historical context, our study provides valuable insights into the biogeochemical consequences of ongoing and future climate change in Arctic fjord systems.

1-61

Spatiotemporal distribution of marine aerosols and gaseous species over the North Pacific Ocean

Oh, Seungmee., Kim, Yong Pyo., Park, Ki-Tae., **Seo, Min Ju., Park, Jiyeon., Yoon, Young Jun.** and 2 others.
The Science of the total environment. 2025. 965: 178642–178642.
doi: 10.1016/j.scitotenv.2025.178642.

Observational studies of marine aerosols are essential for understanding the global aerosol budget and its environmental impacts. This study presents simultaneous in-situ measurements of major ionic components (Cl⁻, NO₃⁻, SO₄²⁻, NH₄⁺, K⁺, Ca₂⁺, Na⁺, and Mg₂⁺) in aerosols and gaseous species (HCl, HNO₃, HONO, SO₂, and NH₃) over the North Pacific Ocean from July 4 to 15 and September 19 to October 3, 2022. Using high temporal resolution instruments aboard the Republic of Korea’s icebreaker research vessel Araon, this study aimed to (1) report the spatial and temporal distributions of aerosols and gaseous species, (2) estimate the source contributions of continental anthropogenic pollutants, and

(3) assess the influence of aerosol chemical composition and gaseous species on aerosol acidity and water content. Our results revealed a significant decline in anthropogenic contributions, from 72.4±11.2% in the Yellow Sea and East Sea to 32.0±10.8% in the remote Pacific, accompanied by an increase in natural aerosols from 27.6±11.2% to 68.0 ±10.8%. Elevated concentrations of ammonia (NH₃) and nitrous acid (HONO) were observed in the remote ocean, likely associated with the marine environment and biological activities. This increase in NH₃, along with a decrease in sulfate concentrations, contributed to the formation of more alkaline aerosols in the remote ocean. Despite the limited availability of previous studies for direct comparisons, our findings align with observed trends and highlight the unique physicochemical properties of marine aerosols. These results enhance our understanding for the interactions between continental pollutants and marine environments, emphasizing the distinct characteristics of marine aerosols and their potential role in modifying atmospheric processes and influencing climate change.

keywords:
Marine aerosol; Shipborne measurement; North Pacific Ocean; MARGA

1-62 **Geosciences, Multidisciplinary; Oceanography; Paleontology**

Stepwise Cooling Events in the Western Arctic at 8.2 and 4.2 ka: Proxy Development and Application

Suzuki, Kenta., Yamamoto, Masanobu., Park, Yu-Hyeon. and **Nam, Seung-II.**
Paleoceanography and Paleoclimatology. 2025. 40(12).
doi: 10.1029/2025pa005239.

Hydroxylated glycerol dialkyl glycerol tetraether (GDGT)-based proxies have recently been proposed for reconstructing sea surface temperatures (SSTs) in polar oceans, but their reliability has not yet been sufficiently validated. We investigated the spatial distribution of hydroxylated GDGTs in surface sediments from the western Arctic Ocean and the Bering Sea to evaluate the reliability of these proxies and apply them to a sediment core from the Chukchi inner shelf to

reconstruct Holocene SST variability. Among the four tested proxies, the RI-OH’ index shows the strongest correlation with annual mean SST, marking it the most reliable and well-calibrated SST proxy for this region. The RI-OH’-based SST reconstruction reveals two major cooling events at 9.1–8 ka and 4.6–3.7 ka. The earlier event coincides with intensified inflow of cold Pacific Winter Water into the Chukchi Sea, while the latter event is linked to expanded sea ice cover and advance of Alaskan glaciers, likely driven by regional shifts in atmospheric and oceanic circulation. A brief SST decline at 8.3 ka, concurrent with the well-known 8.2 ka event, is observed for the first time in the western Arctic Ocean. The latter cooling episode aligns with the 4.2 ka climate event across the Northern Hemisphere, suggesting that the Arctic climate dynamics contributed to the broader Holocene climatic transition.

keywords:
hydroxylated GDGT; Chukchi sea; Bering sea; surface sediment; RI-OH’; Holocene

1-63 **Meteorology & Atmospheric Sciences**

Substantial shift in phase and amplitude of Indian rainfall beyond 2100

Sharma, Sahil., Ha, Kyung-Ja., Rodgers, Keith B., **Chung, Eui-Seok.** and 2 others.
Npj Climate and Atmospheric Science. 2025. 8(1).
doi: 10.1038/s41612-025-01126-5.

Future changes in rainfall over India are critically important, given their impact on millions of people and the country’s agriculture. However, most studies focus only on changes up to the year 2100, leaving long-term projections largely unexplored. In this study, we leverage a 10-member ensemble with an Earth system model under relatively strong emissions to examine rainfall changes over India to 2500. Our results show a pronounced weakening of large-scale monsoon circulation after 2100, mainly due to increased atmospheric stability caused by rapid warming in the upper troposphere over land. At the same time, the Indian monsoon system expands significantly to the north and west. The northward expansion is driven by accelerated warming over the Tibetan Plateau, which pushes the low-level monsoonal

winds and pressure systems further north. This, along with the development of a strong anomalous anticyclonic circulation over the Bay of Bengal, leads to more consistent upward motion over northern India and a northward expansion of the monsoon. Meanwhile, the westward expansion is linked to uneven warming in the Indian Ocean as the warm pool shifts westwards. These circulation changes, combined with the asymmetric warming pattern, enhance northward moisture transport and contribute to the intensification of rainfall across northwestern and northern India post-2100. These local expressions of large-scale perturbations provide a mechanistic framework for informing long-term mitigation and adaptation efforts for India.

1-64

Multidisciplinary Sciences

Synchronous mid-Holocene marine and terrestrial deglaciation in the Ross Sea, Antarctica

Parker, Rebecca L., Riesselman, Christina R., Truax, Olivia J., Jones, Richard S., **Lee, Jae Il.**, **Lee, Min Kyung.**, Jacobsen, Geraldine., Rosenheim, Brad E., Subt, Cristina., Zawadzki, Atun., Ginnane, Catherine., Naeher, Sebastian., Dunbar, Gavin., McKay, Robert M., Levy, Richard., Turnbull, Jocelyn. and **Yoo, Kyu-Cheul.**
Nature Communications. 2025. 16(1).
doi: 10.1038/s41467-025-65494-5.

The Ross Ice Shelf buttresses ice draining from both East and West Antarctica and its collapse could accelerate the loss of inland ice sheets, rapidly raising sea level. Documenting the location, timing and rate of past glacial retreat can help reveal processes driving rapid mass loss, informing projections of ice sheet responses to a warming climate. Here, we present a record of mid-Holocene ice retreat from the southwestern Ross Sea using facies succession and paired ramped pyrolysis oxidation ¹⁴C/²¹⁰Pb chronology. This record shows rapid ice shelf retreat from 6.9–5.4 cal kyr BP, coeval with thinning of adjacent outlet glaciers. Our findings reconcile earlier discrepancies in terrestrial and marine reconstructions, and indicate that synchronous grounding line retreat from west of Ross Island to the Siple Coast at ~7–6.2 cal kyr BP was likely driven by warm-water incursions, a process active in parts of Antarctica today.

1-65

Engineering, Electrical & Electronic; Geography, Physical; Remote Sensing; Imaging Science & Photographic Technology

Synergistic Effects of Infrared and Microwave Radiance in All-Sky Data Assimilation for a Heavy Precipitation Case Over the Korean Peninsula

Hwang, Jiwon., Park, Hearin., Cha, Dong-hyun., **Choi, Yonghan.** and Park, Sang Seo.
IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing. 2026. 19: 2314–2326.
doi: 10.1109/jstars.2025.3642947.

This study investigates how the integration strategy of infrared (IR) and microwave (MW) brightness temperatures (TBs) influences precipitation forecasting within an all-sky radiance data assimilation framework using a three-dimensional variational method. To improve heavy rainfall forecasts over Korea, we propose an asynchronous assimilation approach in which, when both IR and MW observations are available, only MW TBs are assimilated, and IR TBs are intentionally excluded to reduce redundancy and potential inconsistencies in cloud representation. The case study, focusing on a heavy precipitation event over the Korean Peninsula, employs IR TBs from the Himawari imager (AHI) on Himawari-8 and MW TB from the global precipitation measurement microwave imager and the advanced microwave scanning radiometer 2 aboard the global change observing mission. For comparison, two conventional synchronous strategies are conducted as baselines: one integrating clear-sky IR with all-sky MW, and the other integrating all-sky IR with all-sky MW. Results show that the asynchronous approach achieves the best balance between upper level solid and lower level liquid hydrometeors, leading to the most accurate precipitation forecasts. In contrast, with synchronous approaches, the all-sky IR with MW strategy enhances upper level clouds but reduces low-level moisture, potentially resulting in localized heavy rainfall. Meanwhile, the clear-sky IR with MW approach underestimates upper level cloud structures, which contributes to underestimation of stratiform rainfall. These findings highlight the importance of optimally designed IR–MW integration strategies for this specific heavy precipitation event and provide insights for future improvements in satellite-based precipitation assimilation systems.

keywords:

Infrared radiance; microwave radiance; precipi-tation forecasting; precipi-tation forecasting; satellite all-sky assimilation; three-dimensional variational (3D-Var) data assimilation

1-66

Environmental Sciences; Public, Environmental & Occupational Health

Synergistic effects of oceanic dimethyl sulfide emissions and atmospheric oxidants on new particle formation in the Arctic

Jang, Eunho., Park, Ki-Tae., **Yoon, Young Jun.**, Lee, Kitack., Traversi, Rita., Becagli, Silvia., Severi, Mirko., Tunved, Peter., Krejci, Radovan., Kim, Tae-Wook., Fernandez, Rafael P., Saiz-Lopez, Alfonso. and **Lee, Bang Yong.**
Environmental Research. 2025. 282.
doi: 10.1016/j.envres.2025.122024.

The direct confirmation of the cause-and-effect association between biogenic DMS emissions and the formation of DMS-derived aerosols is challenging because of the complex atmospheric processes involved. Here, we used decade-long field observations and a source-receptor model to pinpoint the key processes controlling the formation of biogenic sulfur aerosols in the Arctic. Our results revealed strong relationships between DMS, MSA, and subsequent new particle formation events during the phytoplankton growing periods. Notably, the efficiency of converting DMS into sulfur particles exhibited substantial variability across various ocean-ice regimes and seasons, depending on atmospheric OH and BrO levels driven by solar radiation and first-year sea ice, respectively. As the Arctic Ocean warms, phytoplankton blooms and the extent of younger sea ice intensifies, leading to increased emissions of DMS and its oxidants into the atmosphere. These combined factors could accelerate biogenic sulfur particle formation, thereby influencing cloud properties and radiative impacts in a warming Arctic.

keywords:

Dimethyl sulfide; Methylsulfonic acid; New particle formation; Sulfur aerosol; Arctic atmosphere

1-67

Astronomy & Astrophysics

The Advanced Mesospheric Temperature Mapper: 2-D Measurement of Mesopause Temperatures at King Sejong Station, Antarctica

Kim, Ji Eun., **Kim, Jeong-Han.**, **Jee, Geonhwa.** and 4 others.
Journal of Astronomy and Space Sciences. 2025. 42(2): 42–61.
doi: 10.5140/JASS.2025.42.2.47.

The tip of the Antarctic Peninsula is widely recognized as one of the most active regions for gravity wave activity. Situated in this dynamic area, the King Sejong Station (KSS: 62.22°S, 58.78°W) serves as an ideal location for investigating gravity wave activity in the mesosphere and lower thermosphere (MLT) region. The Korea Polar Research Institute (KOPRI) has been operating a meteor radar (MR) and an airglow all-sky camera (ASC) at KSS for over a decade, enabling studies on gravity wave activity and MLT dynamics. To enhance these observational capabilities, a new optical instrument, the Advanced Mesospheric Temperature Mapper (AMTM), was installed in January 2023. The KSS-AMTM provides hydroxyl (OH) airglow intensities at approximately 87 km altitude as well as two-dimensional temperature maps at a high temporal resolution. This study presents a brief overview of the observational features and operation of the instrument, alongside initial results obtained over 28 clear nights from February to October 2023. As part of the initial validation, observed mesopause temperatures were compared with data from meteor radar and the Microwave Limb Sounder onboard the Aura satellite

keywords:

AMTM; OH airglow; gravity wave; Antarctic King Sejong station

1-68

Multidisciplinary Sciences

The greater role of Southern Ocean warming compared to Arctic Ocean warming in shifting future tropical rainfall patterns

Jeong, Hyein., Park, Hyo-Seok., Kang, Sarah M. and **Chung, Eui-Seok.**
Nature Communications. 2025. 16(1).
doi: 10.1038/s41467-025-57654-4.

The recent rapid decline in Antarctic sea ice highlights the need to understand whether rising Southern Ocean temperatures have an influence on global climate. While Arctic warming has been extensively studied, the importance of Southern Ocean warming is emerging only now. Here, using multi-model simulations, we show that over 1.5 °C of Southern Ocean surface warming can offset the projected northward shift in tropical zonal-mean precipitation by the mid-21st century, driven by stronger northern high-latitude warming under rising greenhouse gas concentrations. SST nudging experiments suggest that a 1.0 °C warming in the Southern Ocean could impact tropical precipitation as significantly as a 1.5 °C warming in the Arctic. Regionally, Southern Ocean warming increases rainfall in northeastern Brazil while heightening drought risks in the Sahel. These effects are comparable to, or slightly more pronounced than, those caused by a weakening Atlantic Meridional Overturning Circulation and the associated development of the North Atlantic warming hole. Thus, Southern Ocean warming may play a more crucial role than Arctic warming in shaping tropical climate patterns in the coming decades.

1-69

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

The Influence of Australian Bushfire on the Upper Tropospheric CO and Hydrocarbon Distribution in the South Pacific

Lee, Donghee., Kim, Jin-Soo., Walker, Kaley., Sheese, Patrick., Park, Sang Seo., **Choi, Taejin.** and 3 others.
Remote Sensing. 2025. 17(12).
doi: 10.3390/rs17122092.

To determine the long-term effect of Australian bushfires on the upper tropospheric composition in the South Pacific, we investigated the variation in CO and hydrocarbon species in the South Pacific according to the extent of Australian bushfires (2004-2020). We conducted analyses using satellite data on hydrocarbon and CO from the Atmospheric Chemistry Experiment Fourier Transform Spectrometer (ACE-FTS), and on fire (fire count, burned area, and fire radiative power) from the Moderate Resolution Imaging Spectroradiometer (MODIS). Additionally, we

compared the effects of bushfires between Northern and Southeastern Australia (N_Aus and SE_Aus, respectively). Our analyses show that Australian bushfires in austral spring (September to November) result in the largest increase in CO and hydrocarbon species in the South Pacific and even in the west of South America, indicating the trans-Pacific transport of smoke plumes. In addition to HCN (a well-known wildfire indicator), CO and other hydrocarbon species (C₂H₂, C₂H₆, CH₃OH, HCOOH) are also considerably increased by Australian bushfires. A unique finding in this study is that the hydrocarbon increase in the South Pacific mostly relates to the bushfires in N_Aus, implying that we need to be more vigilant of bushfires in N_Aus, although the severe Australian bushfire in 2019-2020 occurred in SE_Aus. Due to the surface conditions in springtime, bushfires on grassland in N_Aus during this time account for most Australian bushfires. All results show that satellite data enables us to assess the long-term effect of bushfires on the air composition over remote areas not having surface monitoring platforms.

keywords:
Australian bushfire; hydrocarbon; South Pacific; ACE-FTS; MODIS

1-70

Environmental Sciences; Geosciences, Multidisciplinary; Meteorology & Atmospheric Sciences

The role of sea ice in present and future Arctic amplification

Chung, Eui-Seok., Kim, Seong-Joong., Ha, Kyung-Ja., Stuecker, Malte F., Lee, Sun-Seon., **Kim, Joo-Hong., Jun, Sang-Yoon.** and Bodai, Tamas.
Communications Earth & Environment. 2025. 6(1).
doi: 10.1038/s43247-025-02834-9.

The importance of sea-ice loss on the Arctic amplification of near-surface warming remains contentious, as Arctic amplification emerges even in model experiments with disabled surface-albedo feedback. Here we show that the characteristics and underlying dynamics of Arctic amplification may change greatly in a future ice-free climate using a series of climate model experiments. Our analysis

indicates that although Arctic amplification continues over the 22nd century, it weakens markedly with a less distinct seasonality in a future ice-free climate. These changes are found to occur because the strength and seasonality of Arctic amplification in the current climate are attributed mainly to a tight coupling between cold-season lapse-rate feedback and sunlit-season surface-albedo feedback. The substantial differences in the characteristics of simulated Arctic amplification between the current and future ice-free climate therefore suggest that the presence of Arctic sea ice is an essential component of the current Arctic amplification regime.

1-71

Multidisciplinary Sciences

Tracing stratospheric transport using subannual plutonium-239 fallout in polar ice cores

Shin, Jinhwa., Lee, Seungmi., Han, Yeongcheol., Hwang, Heejin., Ro, Seokhyun., Hur, Soon Do. and **Hong, Sang-Bum.**
Science Advances. 2025. 11(42).
doi: 10.1126/sciadv.adv1172.

Polar ice cores preserve high-resolution archives of historical atmospheric transport, providing unique insights into long-term stratospheric processes. Here, we present the first subannual plutonium-239 (239Pu) deposition records from Greenland and Antarctic ice cores (1940 to 1980 CE). The limited or delayed fallout from Ivy Mike (1952 CE) compared to Operation Castle (1954 CE), despite their detonation in close proximity, exemplifies how stratospheric circulation and seasonal dynamics create periods of reduced transport to Antarctica. These records also reveal seasonal fallout patterns in Antarctica, with enhanced deposition during austral summers driven by stratosphere-troposphere exchange. Our findings refine current representations of global aerosol dispersion and provide additional constraints for modeling atmospheric processes, particularly those driven by volcanic eruptions and geoengineering interventions.

1-72

Environmental Sciences

Trends and classification of aerosol observed from MODIS sensor over Northern Europe and the Arctic

Han, Kyung M., Jung, Chang H., Song, Chul H., Koo, Ja H., **Yoon, Young J., Lee, Bang Y.** and 2 others.
Atmospheric Pollution Research. 2025. 16(1).
doi: 10.1016/j.apr.2024.102329.

The year-to-year emission trends of air pollutants in the middle latitudes and local Arctic regions affect PM_{2.5} in the Arctic. To understand the aerosol changes in the Arctic caused by these spatial emission characteristics, we investigated the long-term trends of aerosol and categorized aerosol types for nine selected regions over Northern Europe and some parts of the Arctic. The selected Arctic sector does not represent the whole Arctic, and the Arctic in the study includes Greenland, Svalbard, Iceland, and surrounding waters. For the investigation, we used aerosol optical properties observed by the Moderate Resolution Imaging Spectrometer (MODIS) sensor. Our study showed that the long-term analysis of Aerosol Optical Depth (AOD) has an increasing trend over the Arctic regions such as Svalbard (SV), Iceland (IC), Greenland (GL), and Greenland Sea (GLS) at the rates from 0.23 × 10⁻³ to 0.73 × 10⁻³ per year. In contrast, AOD in the some parts of Europe (EU), Northern Europe (NE), Baltic Sea (BS), and Russia (RS) continues to decrease at the rates between-0.84 × 10⁻³ and-2.32 × 10⁻³ per year. Furthermore, aerosol type classification based on specific threshold values of AOD and Angstro(spacing diaeresis)m exponent presents that most aerosols are attributed mainly to 42.23% of continental clean background aerosol (CA) and 32.98% of marine aerosol (MA) for all selected regions. From a seasonal perspective, the contributions of MA are high in winter (78-85%) and less significant in summer (13-17%). On the contrary, CA has a low contribution in winter (5-10%) with dominance in summer (54-63%). These findings can help to improve our understanding of the future climate change and air quality in the Arctic.

keywords:
Classification of aerosol type; Aerosol optical depth; MODIS; AERONET; Arctic

1-73

Meteorology & Atmospheric Sciences

Unraveling the Warm Arctic-Cold Eurasia Pattern: Interplay of Arctic Amplification and Internal Variability in Shaping Midlatitude Weather

Ku, Ho-Young., Wang, Muyin., Overland, James., **Kim, Seong-Joong.** and 2 others.
Journal of Climate. 2025. 38(18): 4975-4987.
doi: 10.1175/jcli-d-24-0599.1.

The warm Arctic–cold Eurasia (WACE) pattern, identified as Arctic warming and midlatitude cooling over recent decades, has been a subject of intense scientific debate regarding its causal relationship and implications for midlatitude weather extremes. This study investigates the primary drivers of WACE, examining the complex interplay between external forcing and internal variability. Using the empirical orthogonal function analysis on 84 years (1941–2024) of winter (DJF) temperature over the Northern Hemisphere, we identify three dominant modes of variability: Arctic amplification (AA), the Arctic Oscillation (AO), and the Barents Oscillation (BO). AA, accounting for 27% of the total variance, captures the dominant warming pattern across the Arctic region and reflects a pronounced long-term trend. In contrast, the AO and BO modes (explaining 13.8% and 9.7%, respectively) exhibit considerable internal variability with negligible long-term trends. From 1990 to 2014, the interaction between these modes largely explains the observed WACE pattern, with AA driving Arctic warming and negative AO phase contributing to Eurasian cooling. Meanwhile, the changepoint detection reveals a shift in Arctic climate regimes, marking a transition from a cold Arctic regime (1947–80) to a warm Arctic regime (2004–24). During the warm regime, weakened meridional potential vorticity gradients and increased East Siberian blocking frequency are observed under negative AO and BO phases. Idealized model experiments corroborate showing that Arctic warming amplifies potential vorticity gradient reductions under negative AO and BO phases. These findings highlight the WACE pattern as driven by the intricate interaction between AA and internal variability, emphasizing the balance between external forcing and internal processes in shaping Arctic climate and midlatitude impacts.

keywords:
Blocking; Climate change; Arctic Oscillation; Internal variability

1-74

Meteorology & Atmospheric Sciences

Variability of solar radiation and cloud cover in the Antarctic Peninsula region

Szysmszova, Simona., Laska, Kamil., **Kim, Seong-Joong.** and **Park, Sang-Jong.**
Atmospheric Research. 2025. 316.
doi: 10.1016/j.atmosres.2025.107940.

Solar radiation is a key driver of many physical, chemical and biological processes in Antarctic ecosystems and the main component of the surface energy budget. The downward shortwave radiation (DSR) flux varies greatly in the Antarctic Peninsula region due to cloud cover changes, resulting from climate differences between eastern and western coasts. The DSR intensity was measured using A-class pyranometers at the J.G. Mendel (JGM) station located on the northeastern part of the Antarctic Peninsula and at the King Sejong (KSJ) station located on the western part for the period 2011–2016. The influence of the cloud cover on the DSR flux was evaluated using the cloud modification factor calculated for both stations. The effect of surface pressure, water vapour, albedo, cloud cover, ozone and solar zenith angle was examined using partial correlation. We found a 29 %–higher DSR intensity at the JGM station, while the cloud cover was higher at the KSJ station, with a 28 %–lower cloud modification factor compared with the JGM station. At both stations, the DSR variability was affected mainly by the solar zenith angle, followed by cloud cover at the JGM station, whereas the influence of cloud cover and water vapour was similar at the KSJ station. The effect of the albedo was significant for most of the year at the JGM station but only in the winter at the KSJ station. These results reveal significant differences in climate conditions between the western and eastern coasts, which are reflected in local atmospheric and cryospheric processes.

keywords:
Solar radiation; Cloud cover; Cloud modification factor; James Ross Island; King George Island; Antarctic Peninsula

1-75

Environmental Sciences; Environmental Studies; Meteorology & Atmospheric Sciences

Wildfires offset the increasing but spatially heterogeneous Arctic-boreal CO₂ uptake

Virkkala, Anna-Maria., Rogers, Brendan M., Watts, Jennifer D., Arndt, Kyle A., Potter, Stefano., Wargowsky, Isabel., Schuur, Edward A. G., See, Craig R., Mauritz, Marguerite., Boike, Julia., Bret-Harte, M. Sydonia., Burke, Eleanor J., Burrell, Arden., Chae, Namyi., Chatterjee, Abhishek., Chevallier, Frederic., Christensen, Torben R., Commane, Roisin., Dolman, Han., Edgar, Colin W., Elberling, Bo., Emmerton, Craig A., Euskirchen, Eugenie S., Feng, Liang., Gockede, Mathias., Grelle, Achim., Helbig, Manuel., Holl, David., Jarveoja, Jarvi., Karsanaev, Sergey V., Kobayashi, Hideki., Kutzbach, Lars., Liu, Junjie., Luijkx, Ingrid T., Lopez-Blanco, Efren., Lunneberg, Kyle., Mammarella, Ivan., Marushchak, Maija E., Mastepanov, Mikhail., Matsuura, Yojiro., Maximov, Trofim C., Merbold, Lutz., Meyer, Gesa., Nilsson, Mats B., Niwa, Yosuke., Oechel, Walter., Palmer, Paul I., **Park, Sang-Jong.** and 15 others.
Nature Climate Change. 2025. 15(2).
doi: 10.1038/s41558-024-02234-5.

The Arctic–Boreal Zone is rapidly warming, impacting its large soil carbon stocks. Here we use a new compilation of terrestrial ecosystem CO₂ fluxes, geospatial datasets and random forest models to show that although the Arctic–Boreal Zone was overall an increasing terrestrial CO₂ sink from 2001 to 2020 (mean ± standard deviation in net ecosystem exchange, −548 ± 140 Tg C yr^{−1}; trend, −14 Tg C yr^{−1}; P < 0.001), more than 30% of the region was a net CO₂ source. Tundra regions may have already started to function on average as CO₂ sources, demonstrating a shift in carbon dynamics. When fire emissions are factored in, the increasing Arctic–Boreal Zone sink is no longer statistically significant (budget, −319 ± 140 Tg C yr^{−1}; trend, −9 Tg C yr^{−1}), and the permafrost region becomes CO₂ neutral (budget, −24 ± 123 Tg C yr^{−1}; trend, −3 Tg C yr^{−1}), underscoring the importance of fire in this region.

1-76

Environmental Sciences; Meteorology & Atmospheric Sciences

Zooplankton grazing increases atmospheric primary aerosol production in the high Arctic

Dall’osto, Manuel., Schmidt, Katrin., Campbell, Robert G., Nomura, Daiki., Park, Jongkwan., **Yoon, Young Jun.** and **Park, Jiyeon.**
Elementa–Science of the Anthropocene. 2025. 13(1).
doi: 10.1525/elementa.2024.00078.

The rapidly changing Arctic has led to evolving natural aerosol emissions, which have strong feedback effects on its climate system. Sea spray aerosol (SSA) particles are a main source of aerosols; they influence cloud formation and cloud properties. Ocean microbiota potentially have an impact on SSA production and flux, but our understanding of the mechanisms is still limited. The potential impact of ocean microbiota on SSA fluxes is still a matter of active research. In this multidisciplinary study conducted in the central Arctic during The Multidisciplinary Drifting Observatory for the Study of Arctic Climate expedition, air–sea interactions were measured by means of in situ bubble–bursting experiments. For the first time, we studied the effect of zooplankton grazing on aerosol production. We found that surface water subjected to zooplankton grazing had a 2–fold increase in SSA production relative to controls without zooplankton. Our biogeochemical results suggest that fresh organic material–possibly dissolved organic carbon and dissolved organic nitrogen from humic–like substances–influences aerosol production. We find a strong chemical–selective process affecting SSA production, with humic–like substances much enriched (40%–280%) relative to protein–like material in the aerosol relative to the water. Our results point to a complex relationship between specific low–concentration organic components in the water phase and its relative capability of being aerosolized, with strong chemically selective processes affecting SSA production. We provide evidence for the role of zooplankton, implying a complex microbial loop that may be regulating the organic component of the SSA production. This study underlines the role of zooplankton in biogeochemical cycles, due to their large biomass and transformation of organic matter during feeding and digestion. Similar processes may occur in other regions with high zooplankton grazing impact, for example, in productive parts of the Southern Ocean and in upwelling regions.

keywords:
Polar aerosol; Polar biogeochemistry; Sea spray aerosol; Ocean–atmosphere interaction

Part 02.

Geo Sciences

2-1

Multidisciplinary Sciences

A fossilized ventral ganglion reveals a chaetognath affinity for Cambrian nectocaridids

Vinther, Jakob., Parry, Luke A., **Lee, Mirinae.**, Nielsen, Morten Lunde., **Oh, Yeongju.**, **Park, Changkun.**, **Kihm, Ji-Hoon.**, DeVivo, Giacinto., Harper, David A. T., Nielsen, Arne T. and **Park, Tae-Yoon S.**
Science Advances. 2025. 11(30).
doi: 10.1126/sciadv.adu6990.

Nectocaridids are enigmatic Palaeozoic animals with a controversial phylogenetic position. Previous hypotheses have placed them in their own phylum, chordates, molluscs (specifically cephalopods), or radiodont panarthropods. We describe here a nectocaridid, *Nektognathus evasmithae* gen. et sp. nov. from the early Cambrian (similar to 519 million years) Sirius Passet Lagerstatte of North Greenland. Key specimens preserve paired, phosphatized arcuate structures consistent with preservation of a ventral ganglion, a feature characteristic of extant and fossil chaetognaths, including the amiskwiid *Timorebestia koprii* also from Sirius Passet. *Nektognathus* shares a gnathostomulid-like jaw apparatus, lateral fins, subterminal anus, and large antennae with *Timorebestia* and *Amiskwia*, placing nectocaridids in the chaetognath stem lineage. The complex sensory anatomy of nectocaridids, which is partially shared with other extinct amiskwiids, highlights a more dynamic predatory lifestyle much higher in the trophic food chain during early chaetognath evolution.

2-2

Geochemistry & Geophysics

A Holocene Paleosecular Variation Record From the Northwestern Ross Sea, Antarctica

Truax, Olivia J., Nelson, Faye., Riesselman, Christina R., Ohneiser, Christian., **Lee, Jae Il.**, **Yoo, Kyu-Cheul.** and 2 others.
Geochemistry Geophysics Geosystems. 2025. 26(2).
doi: 10.1029/2024gc011912.

We present a mid-to-late Holocene record of relative paleosecular variation from the Ross Sea region of Antarctica. The 6,700-year-long record of inclination, declination, and relative paleointensity from a marine sediment core collected near Cape Adare is independently dated using a combination of ramped pyrolysis oxidation and carbonate radiocarbon dates. Agreement between the large-scale features of the relative paleointensity record and the virtual axial geomagnetic dipole moment suggests that changes in the record are dominated by the dipole component of the Earth’s geomagnetic field. Correspondence between the record and a non-independently dated reconstruction from the Antarctic Peninsula indicates regionally coherent changes in the geomagnetic field intensity in the southern high latitudes during the mid-to-late Holocene. The prominent features of the record serve as stratigraphic markers for hard-to-date Antarctic sedimentary records and a constraint on Holocene geomagnetic field behavior when incorporated into the next generation of geomagnetic field models.

2-3

A Study on the Trends of Deep Learning Applications in Geology

Park, Young Kyu. and 2 others.
Korean Journal of Mineralogy and Petrology. 2025. 38(4):405–419.
doi: 10.22807/KJMP.2025.38.4.405

Deep Learning has recently become an important tool for solving problems in geology as Artificial Intelligence (AI). Geological research typically deals with large datasets and complex patterns. Deep learning algorithms applied to these challenges have substantially improved analytical accuracy and

efficiency compared to traditional methods. In this study, we introduce development process of Deep Learning algorithms that can be applied in geology (problem definition and topic selection; data collection and refinement; algorithms model design and training; algorithms model optimization; deployment and interpretation). Furthermore, we introduce Deep Learning architectures and their applications in various geological fields, including mineral exploration, satellite image analysis and seismic waveform analysis. Overall, this study highlights the potential of deep learning to serve as a robust tool for understanding and predicting geological phenomena.

keywords:

Deep learning; Geology; AI; Geological data analysis; Machine learning

2-4

Geosciences, Multidisciplinary

Airborne and Spaceborne Mapping and Analysis of the Subglacial Lake D2 in David Glacier, Terra Nova Bay, Antarctica

Ju, Hyeontae., **Kang, Seung-Goo.**, Han, Hyangsun., Beem, Lucas H., Ng, Gregory., Chan, Kristian., Kim, Taewook., **Lee, Joohan.**, **Lee, Jongik.** and 2 others.
Journal of Geophysical Research–Earth Surface. 2025. 130(6).
doi: 10.1029/2024jf008142.

During the 2018–2019 Antarctic summer, the Korea Polar Research Institute and the University of Texas Institute for Geophysics collaborated on a helicopter-based ice-penetrating radar (IPR) survey over the active subglacial lake D2 (SLD2), located in the midstream of the David Glacier, Terra Nova Bay, Antarctica. This study investigates the relationship between SLD2 water levels and fluctuations in glacial surface elevation (up to 3.6 m) and delineates subglacial lakes within the study area. We provide a comprehensive analysis based on integrated data from IPR (2018), Sentinel-1 double-differential interferogram synthetic aperture radar (DDInSAR) (2017–2022), ICESat-2 laser altimeter (2019–2022), and KOMPSAT-5 synthetic aperture radar (2021 and 2023). The concave bedrock structure and low hydraulic head areas concentrate subglacial meltwater, facilitating water accumulation and retention, forming a lake. The SLD2 lake complex is identified based on bed topography, hydraulic gradient, and relative bed reflection intensity. Its area is approximately 1/9.2 of the lake area

estimated through remote sensing. Our analysis suggests that variations in water supply and discharge along the subglacial channel network influence lake water levels, as evidenced by a surface elevation increase of up to 3.69 m in the SLD2 area from 2019 to 2022. Additionally, the presence of crevasses and incoherence in the DDInSAR imagery suggests that these subglacial lakes impact glacier flow velocity.

2-5

Chemistry, Analytical

Allanite U-Pb step-leaching ages of metapelites in the Imjingang belt, central Korea

Han, Seunghee., Kim, Yoonsup., Kim, Taehoon. and **Lee, Mi Jung.**
Journal of Analytical Science and Technology. 2025. 16(1).
doi: 10.1186/s40543-025-00482-4.

Background Allanite is a LREE-rich epidote-group mineral, and a potential chronometer for the greenschist-facies metamorphism. However, owing to the metamict nature of allanite, it is extremely difficult to secure sufficient amounts of mineral separates from metapelites. Thus, we applied the U-Pb step-leaching (UPbSL) technique to determine the metamorphic age of allanite inclusions in garnet porphyroblasts, 1–2 mm long in diameter, separated from kyanite-staurolite-garnet schists in the Imjingang belt, central Korea. Methods The UPbSL dating on the garnet separates was performed with seven individual steps as a function of variable type and concentration of acid, temperature, and time. In particular, HCl was used to dissolve garnet separates in the steps 1 to 4, whereas HBr in the rest of steps. Leaching by HF was avoided in the experiments to minimize detrital zircon contribution to the U-Pb isotopic systematics. Following the UPbSL, column chromatography was carried out using the AG1X 100–200 mesh ion exchange resin with 6 N HCl for Pb and the AG1X 200–400 one with 8 N HNO3 and distilled water for U, respectively. The U-Pb isotopic compositions of leachates at each step were measured using thermal ionization mass spectrometry in addition to ²⁰⁸Pb–²³⁵U and ²⁰⁵Pb–²³⁵U mixed spikes. Results The U and Pb concentrations in the

UPbSL analyses range from the several tens to hundreds ppb, and isotopic fractionation in this study was minor including $^{238}\text{U}/^{204}\text{Pb}$ ratios in the range of ~10–100 which resulted in large uncertainties in the errorchron ages. The $^{208}\text{Pb}/^{206}\text{Pb}$ and $^{207}\text{Pb}/^{206}\text{Pb}$ ratios in the analyses show a linear correlation which suggests a mixing between the single radiogenic Pb and common Pb components. Errorchron ages of 269 ± 140 Ma (2σ) and 290 ± 280 Ma (2σ) were obtained from the 100–mg and 200–mg UPbSL experiments with initial ratios of 17.4 ± 1.4 and 17.3 ± 2.5 , respectively. Conclusions The UPbSL data in this study demonstrate that both U and radiogenic Pb originate predominantly from allanite inclusions within garnet and yielded the U–Pb allanite age of ~270–290 Ma. The ages are similar to the chemical age of monazite (255 ± 8 Ma) in the same schistose unit and the U–Pb age of zircon (253 ± 2 Ma) from a paragneiss in the Imjingang belt. Therefore, the UPbSL is applicable to measuring metamorphic ages of allanite in metapelites.

keywords:
Allanite; Garnet; Step leaching; U–Pb errorchron age; Metapelites

2-6 Geochemistry & Geophysics

Antarctic Magnetic Anomalies and Their Gradients Differentially Reduced to the Geomagnetic Pole for Enhanced Crustal Analysis

Kim, Hyung Rae., Golynsky, Alexander V., Golynsky, Dmitry., Leftwich, T. E., Von Frese, R. R. B., **Hong, Jong Kuk.** and Lee, Minjae.
Journal of Geophysical Research–Solid Earth. 2025. 130(5).
doi: 10.1029/2024jb029687.

To facilitate geological studies of the Antarctic region south of 60 degrees S, equivalent point magnetic dipole inversion was used to produce the comprehensive airborne–to–satellite altitude ADMAP–2s magnetic anomaly model. These spherical coordinate anomaly predictions jointly match the crustal magnetic anomalies gridded at 250 km above the Earth’s mean geocentric radius (mgr) from the magnetometer observations of the Swarm satellite mission and at the mgr from the Antarctic Digital Magnetic Anomaly Project’s (ADMAP) second–

generation magnetic anomaly compilation (ADMAP–2) of over 3.5 million line–km of aeromagnetic and shipborne survey data. The present study investigates the utility of point dipole modeling for differentially reducing the magnetic anomalies to the pole and estimating their first and second order radial (i.e., locally vertical) derivative anomalies. Where sufficiently accurate, these radially polarized magnetic anomalies and gradients help constrain the possible depths and lateral limits of the crustal magnetic anomaly sources for Antarctica and the circumjacent southern Atlantic, Indian, and Pacific oceans. For East Antarctica, the anomalies help resolve relatively ancient cratonic boundaries and related sutures and magmatic intrusions, whereas at satellite altitude, they also offer insights on variations of lithospheric heat flow.

keywords:
magnetic anomalies; Antarctic; ADMAP; differentially reduced to pole; Swarm satellites

2-7 Multidisciplinary Sciences

Bedmap3 updated ice bed, surface and thickness gridded datasets for Antarctica

Pritchard, Hamish D., Fretwell, Peter T., Fremand, Alice C., Bodart, Julien A., Kirkham, James D., Aitken, Alan., Bamber, Jonathan., Bell, Robin., Bianchi, Cesidio., Bingham, Robert G., Blankenship, Donald D., Casassa, Gino., Christianson, Knut., Conway, Howard., Corr, Hugh F. J., Cui, Xiangbin., Damaske, Detlef., Damm, Volkmar., Dorschel, Boris., Drews, Reinhard., Eagles, Graeme., Eisen, Olaf., Eisermann, Hannes., Ferraccioli, Fausto., Field, Elena., Forsberg, Rene., Franke, Steven., Goel, Vikram., Gogineni, Siva Prasad., Greenbaum, Jamin., Hills, Benjamin., Hindmarsh, Richard C. A., Hoffman, Andrew O., Holschuh, Nicholas., Holt, John W., Humbert, Angelika., Jacobel, Robert W., Jansen, Daniela., Jenkins, Adrian., Jokat, Wilfried., Jong, Lenneke., Jordan, Tom A., King, Edward C., Kohler, Jack., Krabill, William., Maton, Josephine., Gillespie, Mette Kusk., Langley, Kirsty., **Lee, Joohan.** and 33 others.
Scientific Data. 2025. 12(1).
doi: 10.1038/s41597-025-04672-y.

We present Bedmap3, the latest suite of gridded products describing surface elevation, ice–thickness and the seafloor and subglacial bed elevation of the Antarctic south of 60

degrees S. Bedmap3 incorporates and adds to all post–1950s datasets previously used for Bedmap2, including 84 new aero–geophysical surveys by 15 data providers, an additional 52 million data points and 1.9 million line–kilometres of measurement. These efforts have filled notable gaps including in major mountain ranges and the deep interior of East Antarctica, along West Antarctic coastlines and on the Antarctic Peninsula. Our new Bedmap3/RINGS grounding line similarly consolidates multiple recent mappings into a single, spatially coherent feature. Combined with updated maps of surface topography, ice shelf thickness, rock outcrops and bathymetry, Bedmap3 reveals in much greater detail the subglacial landscape and distribution of Antarctica’s ice, providing new opportunities to interpret continental–scale landscape evolution and to model the past and future evolution of the Antarctic ice sheets.

2-8 Geochemistry & Geophysics

Chemical and Structural Evidence for Melt-Induced Amorphization of Alkali Feldspar in Lunar Meteorite DEW 12007: Insight into Shock Amorphization Mechanisms

Kim, Hyeong-Gyu., **Park, Changkun.**, Kim, Eun Jeong., Park, Sun Young., **Kim, Hwayoung.** and Kim, Hyun Na.
Journal of Petrology. 2025. 66(9).
doi: 10.1093/petrology/egaf074.

Feldspar minerals, including alkali feldspar and plagioclase, commonly undergo shock–induced amorphization, making them key indicators for reconstructing the impact history and thermal evolution of planetary materials. This study focuses on alkali feldspar in the lunar meteorite DEW 12007 to elucidate the mechanisms of amorphization using Raman spectroscopy and electron probe microanalysis. Our findings reveal a strong correlation between crystallinity and chemical composition, with Na enrichment and K depletion observed in amorphous regions compared to the crystalline counterparts. These compositional shifts can be explained by the chemical behavior of sanidine–albite system, supporting impact melt–induced partial amorphization as the dominant mechanism. The crystalline counterparts near amorphous boundaries exhibit increased K content, reflecting the compositional redistribution during partial melting and quenching. To assess the utility of these findings,

feldspar from the well–documented L6 ordinary chondrites were analyzed. Feldspars from the ordinary chondrites showed opposite trends, exhibiting the amorphous phases enriched in K and depleted in Na relative to the crystalline counterparts. These differences are consistent with the chemical behavior of sanidine–albite system. This ability has a potential to differentiate whether maskelynite was formed via solid–state transformation or melt–quenching processes, providing critical insights into the impact history and thermal evolution of the rocky crusts of the Moon and other solar system bodies. Extending this framework to other meteorites, returned samples, and planetary bodies enhances our understanding of impact processes, offering a robust approach for unraveling the complex interplay between shock metamorphism and planetary evolution.

keywords:
alkali feldspar; amorphization; amorphous feldspar; lunar meteorite; partial melting

2-9 Geosciences, Multidisciplinary; Meteorology & Atmospheric Sciences

Clay minerals and elemental composition of smectites in the marine sediment from the southwest Ross Sea and implication for their provenance and sediment input changes after the last glacial period

Park, Young Kyu., Lee, Jae Il., Yoo, Kyu–Cheul. and 2 others.
Geoscience Letters. 2025. 12(1).
doi: 10.1186/s40562-025-00381-x.

Smectite in detrital sediments can be composed of various proportions of Al, Mg, and Fe, indicating the sediment sources derived from the bedrock or from the sedimentary strata. Comparing the elemental composition of smectites can help to define sediment provenance in relation to paleo–environmental changes, especially glacier retreat. However, few studies of mineralogical and geochemical properties of clay minerals in marine sediment from the southwest Ross Sea have been conducted. Here, this study investigates the clay mineralogy and elemental composition of smectites during the last glacial period to the latest Holocene sediment in cores RS15–GC16B

(southern Drygalski Trough), RS15–GC78 (offshore of Mawson Glacier), and RS15–GC80 (Mackay Glacier front) deposited in the southwest Ross Sea sector. It might be necessary to understand variabilities and distribution of elemental compositions in smectites in the southwest Ross Sea and their provenance, and to reconstruct sediment transport through the glacier changes. Indeed, two types of smectite (Al-rich and Al-Fe rich) were identified in core RS15–GC16B from the southern Drygalski Trough, indicating that some sediments were supplied from glaciogenic debris containing Al-Fe rich smectite by the northward advance of the East Antarctic glacier during the glacial period. In contrast, only Al-rich smectite in core RS15–GC16B (the southern Drygalski Trough) were identified during the deglacial period. Al-rich smectite is probably originated from subglacial erosion of sedimentary strata from the David Glacier. This finding implies different sources during glacial and deglacial period deposited at core RS15–GC16B, although that show only minor difference in smectite contents. Overall, these results highlight importance of analysis of the elemental composition of smectites in tracing sediment sources and their transport pathways during the East Antarctic glacier retreat.

keywords:
Southwest Ross Sea; Smectite; Elemental composition; East Antarctic glacier; Clay mineral provenance; Antarctica

2-10 **Geochemistry & Geophysics; Geology**

Determination of Ground Subsidence Around Snow Fences in the Arctic Region

Kim, Kwansoo., Ju, Hyeontae., Chi, Junhwa., Jung, Ji Young., Nam, Sungjin., Park, Sang-Jong., Dafflon, Baptiste., Lee, Joohan. and Kim, Won-Ki.
Lithosphere. 2025. 2025(1).
doi: 10.2113/2025/lithosphere_2024_215.

In this study, we analyzed the effects of snow cover changes caused by snow fences (SFs) installed in 2017 in the Alaskan tundra to examine ground subsidence. Digital surface model data obtained through LiDAR-based remote sensing in 2019 and 2022, combined with a field survey in 2021, revealed approximately 0.2 m of ground subsidence around the SF. To investigate the relationship between SF-induced

snow cover changes and ground subsidence, geophysical methods, electrical resistivity tomography (ERT) and ground-penetrating radar (GPR), were applied in 2023 to analyze subsurface characteristics. The increased snow cover due to the SF-enhanced insulation, delaying the penetration of winter cold into the subsurface. This delay caused subsurface temperatures to decrease more slowly, melting the upper permafrost and increasing the thickness of the active layer. ERT and GPR surveys well delineated the boundary between the active layer and permafrost, confirming that the increased snow cover thickened the active layer. This thickening led to the melting of pore ice, causing water runoff and ground compaction, which resulted in subsidence. The runoff also formed channels flowing eastward over the SF. This study highlights how changes in snow cover can influence active layer properties, leading to localized environmental changes and ground subsidence.

2-11 **Engineering, Electrical & Electronic; Geography, Physical; Remote Sensing; Imaging Science & Photographic Technology**

Development of Field-Deployable Detection Models for Asbestos Host Rocks Using Close-Range Hyperspectral Imaging and Diverse Lithological Training Data

Ngolo, Grace Malvine Moughoa Boussoughou., Yu, Jaehyung., Wang, Lei. and Kim, Hyun-Cheol.
IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing. 2025. 18: 23526–23547.
doi: 10.1109/jstars.2025.3605359.

This study presents a field-applicable detection models for host rocks of naturally occurring asbestos (NOA) through hyperspectral imaging and machine learning. We developed detection models using the most comprehensive dataset to date: 104 rock samples spanning 27 distinct lithologies, including 5 NOA-associated and 22 non-NOA rock types representing prevalent lithospheric formations. Sample characterization integrated visual inspection, X-ray fluorescence, X-ray diffraction, and spectral analyses, revealing distinctive signatures in NOA-associated rocks. High MgO content emerged as a crucial indicator for asbestos formation. NOA-carbonate spectral characteristics were primarily

controlled by calcite, dolomite, and tremolite asbestos, while NOA-ultramafic spectral responses were governed by chrysotile, lizardite, olivine, and pyroxene. Traditional absorption-based methods (SAM, MSRFF) demonstrated poor performance due to their reliance on endmember spectra and inability to manage complex spectral variability. Machine and deep learning approaches showed superior performance by effectively leveraging key spectral bands: MgOH and CO₃²⁻ for NOA-carbonate detection and MgOH and FeOH for NOA-ultramafic identification. The 3-D CNN model achieved superior performance (93.6% accuracy, Kappa coefficient: 0.88), excelling in discriminating subtle mineralogical variations through complex spatial-spectral pattern recognition. Field validation using 2 NOA and 3 non-NOA outcrops confirmed the model's reliability (89.2%–99.6% accuracy). Given the fact that the model utilizes mineral absorptions while excluding atmospheric bands and has been field-tested, the model can be applied to NOA surveys in various contexts, including construction projects and underground development.

keywords:
Detection models; hyperspectral spectroscopy; naturally occurring asbestos (NOA); random forest (RF) ; support vector machine (SVM)

2-12 **Chemistry, Multidisciplinary; Geochemistry & Geophysics**

Diffuse Soil Degassing in Hydrothermal Areas of Mt. Melbourne, Antarctica: Insights for the Understanding of Cryovolcanism on Earth

Lee, Hyunwoo., Lee, Wonhee., Lee, Mi Jung. and 6 others.
Acs Earth and Space Chemistry. 2025. 9(8): 2092–2101.
doi: 10.1021/acsearthspacechem.5c00099.

Cryovolcanism is a phenomenon reported in dwarf planets and satellites in the solar system and is characterized by the eruptions of volatiles under low-temperature conditions. However, there are clearly limitations to understanding it fully from observations far from Earth. From this point of view, Antarctica is one of the most extreme environments on Earth and is a very important region for modeling the extraterrestrial

environment. Here, we report a maximum soil CO₂ flux value of 6120 g m⁻² d⁻¹ and a total CO₂ output of 8355 t d⁻¹ from the hydrothermal environment (up to 57.6°C) of Mt. Melbourne, an active volcano located in Antarctica. In addition, fumarolic gases have $\delta^{13}\text{C}$ values of –13.9 to –4.2‰ with CO₂ concentrations of 21.2–36.2 vol %. The corrected helium isotope ratios (R_c/R_a) of the gases are up to 2.21, indicating the magma degassing of Mt. Melbourne. However, hydrogen and oxygen isotopes of the ice samples inside the ice caves and ice towers in the hydrothermal region, similar to their surroundings, suggest that they are of largely atmospheric origin. Nevertheless, the circulated water caused hydrothermal alteration, producing minerals such as kaolinite and gibbsite, which greatly affected the moss habitat and microbial distribution of small greenhouse systems. Thus, the observations in this Antarctic hydrothermal system could potentially provide clues about extraterrestrial biological activity through cryovolcanism.

keywords:
hydrothermal degassing; carbon dioxide; helium; cryovolcanism; Mt. Melbourne; Antarctica

2-13 **Geography, Physical; Geosciences, Multidisciplinary; Paleontology**

Early aculiferan diversification shaped by *Ægir-lapetus* palaeogeography: Insights from North Greenland (Cambrian Series 2, Stage 4)

Oh, Yeongju., Park, Tae-Yoon S. and Peel, John S.
Palaeogeography Palaeoclimatology Palaeoecology. 2025. 680.
doi: 10.1016/j.palaeo.2025.113338.

Aculifera, comprising Polyplacophora (chitons) and Aplacophora, is one of two major molluscan clades, characterised by a scleritome of mineralised sclerites or plates. Their early evolutionary history is poorly understood due to sparse fossil records bridging possible Terreneuvian (early Cambrian) stem-group taxa and Furongian (late Cambrian) chiton-like articulated representatives. Here, we describe seven species in five genera from the Aftenstjernesø Formation (Cambrian Series 2, Stage 4) of North Greenland, including a second species, *Qaleruaqia bronlundensis* sp. nov., of the oldest *paleoloricate*, *Qaleruaqia* sp.; the sachitid *Hippopharangites groenlandicus*,

Hippopharangites? sp.; a possible intermediate plate of a chiton-like scleritome, *Avannaplex midsommersoensis* gen. et sp. nov.; and possible aculiferans *Ocruranus? kangerluk* and *Xianfengella yatesi*. Morphological comparisons of the North Greenland assemblage reveal strong affinities with Terreneuvian taxa, including maikhanellids and the *Ocruranus–Eohalobia* group, supporting their interpretation as stem-group aculiferans. A palaeobiogeographic analysis using 650 global occurrences of Cambro-Ordovician taxa shows that the *Ægir* Ocean as a principal dispersal corridor for early diversification of aculifera. During the Terreneuvian, aculiferans were widespread along *Ægir* margins but rare in Laurentia, likely due to isolation by the Iapetus Ocean. From Cambrian Series 2 onward, increased connectivity and expanded low-latitude carbonate platforms fostered diversification in eastern Laurentia, including North Greenland. This assemblage from North Greenland bridges a critical spatio-temporal and morphological gap between the earliest Cambrian taxa and Furongian paleoloricates, offering new insight into aculiferan diversification and palaeobiogeography.

keywords:
North Greenland; Aculiferan molluscs; Cambrian; Small shelly fossils; Early aculiferan diversification

2-14

Geology

Evidence of High-Pressure Metamorphism Along the Mahanadi Shear Zone in the Eastern Ghats Province, Eastern India: Implications on Tectonics and Continental Assembly Involving India and East Antarctica

Karmakar, Shuvankar., Bose, Sankar., Ghosh, Gautam., Das, Kaushik., **Sorcar, Nilanjana.** and Mukherjee, Sneha.
Journal of Metamorphic Geology. 2025. 43(2): 123–160.
doi: 10.1111/jmg.12797.

A suite of mafic granulite enclaves within mylonitised felsic gneiss occurring along the E–W trending Mahanadi Shear Zone of the Eastern Ghats Province preserves evidence of high-pressure metamorphism. Garnet-clinopyroxene-bearing mafic granulite contains a mineral assemblage of garnet + clinopyroxene + plagioclase + quartz + rutile which was formed after dehydration melting of a hornblende-bearing protolith

during M1 metamorphism that peaked at 1.1–1.4 GPa, 760° C–840°C. The retrograde stage (M_{1R}) is marked by the formation of hornblende and symplectic intergrowth of clinopyroxene + plagioclase + orthopyroxene after garnet at 0.8–0.9 GPa, 760° C–810°C, suggesting an isothermal decompression type *P–T* path. The whole rock trace element and REE characteristics suggest a MORB–OIB protolith for the mafic granulites. The host felsic gneiss has a granitic protolith which was emplaced in an arc setting. The rocks exposed south of the Mahanadi Shear Zone in the Phulbani domain are represented by granulites with contrasting metamorphic characteristics. The garnet–orthopyroxene-bearing mafic granulite within coarse-grained charnockite and the aluminous granulite within felsic gneiss show evidence of biotite dehydration melting. The peak M1 assemblage in the aluminous granulite is represented by the assemblage spinel + garnet + quartz + plagioclase + K-feldspar which was stable at 0.70–0.74 GPa, 904°C–935°C. M1R in this rock is characterised by coronas of garnet and sillimanite over spinel and the formation of matrix biotite at 707°C–806° C by near-isobaric cooling. Similar isobaric cooling has been documented from the formation of garnet, clinopyroxene and quartz coronas on orthopyroxene in mafic granulite and garnet and quartz coronas on clinopyroxene, wollastonite and calcite in calc-silicate granulite. The juxtaposition of lower crustal rocks showing clockwise and counterclockwise *P–T* paths across the Mahanadi Shear Zone implies a paired metamorphic character in a subduction-collision setting. Zircon U–Pb and monazite U–Th–total Pb data show a complex history of the rock suite. The enclave suite of rocks within the Mahanadi Shear Zone underwent peak M₁ metamorphism at ca. 980–960 Ma which was followed by decompression to a shallower level by ca. 960 Ma when the host granitic magma crystallised. Rocks occurring in the Phulbani domain (southerly placed crustal domain), on the other hand, underwent ultrahigh temperature metamorphism at shallower crustal levels broadly at the same time. We argue that the southern Phulbani domain of the Eastern Ghats Province, India, collided with the Angul–Prydz domain of the Rayner Province, East Antarctica which eventually caused underthrusting of the former below the latter across the Mahanadi Shear Zone. In the context of the Eastern Ghats–Rayner reconstruction, this indicates the closure of the intervening Mawson Sea. A second metamorphic event (M₂) reworked the exhumed deep crustal rocks at ca. 900 Ma during the final docking of the Eastern Ghats–Rayner belt against cratonic India. Our results clearly show that the Angul domain is an exotic block, and the Mahanadi Shear Zone is a terrane boundary shear zone suturing discrete domains of the Rayner–Eastern Ghats orogen.

keywords:
collisional tectonics; exhumation; high-pressure metamorphism; isothermal decompression; mafic granulite; Rayner–Eastern Ghats orogen

2-15

Geology; Mineralogy; Mining & Mineral Processing

Fluid phase separation promotes mineralization of epithermal base metal sulfides: A case study from the Central Seruyan Pb–Zn–Cu deposit in Kalimantan, Indonesia

Choi, Yuri., Lee, Insung., Seo, Jung Hun., Guillong, Marcel., **Lee, Mi Jung.** and **Han, Seunghee.**
Ore Geology Reviews. 2025. 186.
doi: 10.1016/j.oregeorev.2025.106925.

The Central Seruyan Pb–Zn–Cu deposit in Central Kalimantan is an epithermal deposit situated within the Central Borneo metallogenic belt. To develop a genetic model for this deposit and provide insights for future exploration, we conducted studies on petrography, fluid inclusions, trace element geochemistry of sulfide minerals, and Pb isotope compositions. The mineralization can be categorized into four hydrothermal stages, based on the characteristics of alteration and ore mineral assemblages. The primary base metal sulfide minerals in the main ore stage include galena, sphalerite, and chalcopyrite, with minor amounts of covellite and tetrahedrite-tennantite. The principal Pb–Zn–Cu mineralization occurred under temperatures ranging from 170 to 320 degrees C at an apparent depth of 0.1 to 0.4 km from the paleosurface. Petrographic analysis and fluid inclusion microthermometry suggest that fluid boiling and decompression-induced quenching were the dominant processes driving base metal mineralization. The heterogeneous trace element distribution and color zonation observed in sulfide minerals further indicate an abrupt temperature change during the main mineralization stage. Arsenic and gold zonation in pyrite, along with indium and gallium zonation in sphalerite, suggest rapid temperature fluctuations likely associated with boiling. Microanalyses of fluid inclusions in sphalerite reveal that the ore-forming fluids originated from subduction-related magmas undergoing batholith-scale fractionation. For future exploration, we

recommend targeting SW–NE trending faults, which may have facilitated decompression and subsequent boiling.

keywords:
Magmatic-hydrothermal fluid; Pb–Zn–Cu epithermal deposit; Fluid inclusion; Trace element geochemistry; Pb isotope; Phase separation

2-16

Geological Age Data of the Ross Orogeny in the Terra Nova Intrusive Complex, Northern Victoria Land, Antarctica

Yi, Sang-Bong. and **Lee, Mi Jung.**
Geo Data. 2025. 7(1): 1–8.
doi: 10.22761/gd.2025.0001.

This study aims to establish the timing of the formation of the Terra Nova Intrusive Complex (TNIC), located in Terra Nova Bay, northern Victoria Land, Antarctica. The TNIC is paleogeographically situated inland of the Wilson Terrane of northern Victoria Land and was formed during the Paleozoic Ross Orogeny. This study obtained and compiled sensitive high-resolution ion microprobe zircon U–Pb ages for five intrusive bodies in the south-central part of the TNIC. The results clarify the formation age (about 530–470 Ma) of the TNIC and the interrelationships among the various intrusive units, especially those in the south-central region. The Confusion Intrusive Unit was emplaced at 520–515 Ma. The Russell Gabbro intruded into the Confusion Intrusive Unit at 501±3 Ma. Approximately at the same time (about 500 Ma), the Vegetation Intrusive Unit formed, followed by the Abbott Intrusive Unit at about 485 Ma. These findings provide valuable data for interpreting the geological development of the Antarctic Continent and the evolutionary history of the Ross Orogeny.

keywords:
Antarctica; Northern Victoria Land; Ross Orogeny; Terra Nova Intrusive Complex; Zircon U–Pb age

2-17

Geosciences, Multidisciplinary; Marine & Freshwater Biology; Oceanography

Grain-size and geochemical evidence for sediment transport mechanisms in the northeastern part of the East Siberian Sea and on the adjacent continental slope

Ovsepyan, Ekaterina., Dorokhova, Evgeniia., Ovsepyan, Yaroslav., Aliev, Ramiz. and **Jin, Young Keun.**
Journal of Marine Systems. 2025. 252.
doi: 10.1016/j.jmarsys.2025.104140.

Grain-size analyses, end-member modeling, X-ray fluorescence, and radionuclide activity measurements were conducted on sediment minicores collected from the middle-outer shelf of the East Siberian Sea (ESS) and the upper part of the adjacent continental slope to elucidate the sedimentation mechanisms in this poorly studied region. The grain-size data demonstrate that clayey silt and silt strongly dominate on the ESS shelf and the continental slope. In contrast, sandy silt has a patchy distribution. End-member modeling, applied here for the first time, indicates that sea ice (frazil and anchor ice) rafting, and nepheloid transport are the primary processes responsible for distributing sedimentary material across the ESS. The XRF data confirm the results of previous studies, reporting a predominantly lithogenic origin for ESS deposits. Combined grain size and geochemical records suggests that the shelf break area serves as a depocenter for fine silt particles, likely supplied by nepheloid flow, and represents the most productive area in the northeastern ESS. High sea surface productivity likely results from influence of nutrient-rich Pacific-derived waters, the upwelling of transformed Atlantic-derived waters, or a combination of both. The accumulation of the high amount of fine silt near the shelf break is suggested to be related to relatively calm bottom-water conditions, resulting from the potential interaction of the northward-flowing cross-shelf currents and episodic southward-moving compensatory flows. Wind direction is considered a key factor controlling the intensity of fine-grained material distribution by nepheloid flows and anchor ice across the ESS shelf. Sedimentation rates derived from the radionuclide activity measurements vary from 1.3 mm yr⁻¹ on the outer shelf to 1.0 mm yr⁻¹ on the upper continental slope.

keywords:
End-member analysis; Sediment transport; Bottom currents; Sea ice; Late Pleistocene Ice Complex deposits; Sedimentation rates

2-18

Geochemistry & Geophysics

Grenvillian-age deep crustal thrusting, terrane juxtaposition and subduction polarity reversal from the Eastern Ghats Belt, India and its tectonic implications

Karmakar, Shuvankar., Ghosh, Gautam., Bose, Sankar., Mukherjee, Sneha., Sarkar, Dyuti Prakash., **Sorcar, Nilanjana.** and Das, Kaushik.
Tectonophysics. 2025. 911.
doi: 10.1016/j.tecto.2025.230833.

The Proterozoic Eastern Ghats Belt (EGB) represents an arcuate orogenic belt along the east coast of India. Its western boundary is marked by a thrust-cum subduction zone system along which granulite facies rocks of the EGB were thrust over the cratonic rocks while its northern margin with the craton is marked by several crustal-scale shear zones of unresolved kinematic status. The present study generates new structural, kinematic and age data from the Mahanadi Shear Zone (MSZ) of the EGB northern margin that unveils a hitherto undisclosed chronicle of deep crustal thrusting and terrane amalgamation. Correlation of our earlier reported (M1) high-pressure metamorphism (ca. 980-960 Ma) and clockwise pressure-temperature path in the MSZ with the presently reported deep crustal thrusting (600-800°C) at ca. 950-900 Ma led us to infer that the MSZ represents a Grenvillian-age oblique collisional zone signifying northerly underthrusting of the Phulbani domain below the Angul-Tikarpada domains at ca. 980-900 Ma. The proposed SW directed thrusting along MSZ is at variance with the earlier reported coeval NW directed thrusting along the EGB western margin. This new report thus warrants subduction polarity reversal along the two margins of the arcuate EGB orogenic front at the same time frame. The difference in displacement velocity vectors along the two margins was resolved via combined movements on the orogen sub-parallel dextral-slip Koraput Shear Zone and the orogen transverse sinistral-slip Nagavalli-Vamshadhara Shear Zone system. The proposed tectonic model visualises the arcuate shape of the EGB orogenic front as a primary structure inherited from the original craton margin configuration.

keywords:
Deep-crustal thrusting; Kinematic and strain analysis; Oblique collision-transpression; Subduction polarity reversal; Rayner-Eastern Ghats orogen; Oroclinal bend

2-19

Geosciences, Multidisciplinary; Meteorology & Atmospheric Sciences; Water Resources

Harzburgite-dunite transition in the Nidar Ophiolitic Complex, Ladakh, NW India and its effect on olivine crystallographic fabric

Roy, Swarnendu., **Kim, Daeyeong.** and Sen, Koushik.
Physics and Chemistry of the Earth. 2025. 141.
doi: 10.1016/j.pce.2025.104210.

The Nidar Ophiolitic Complex (NOC) of Ladakh, north India, is a well-preserved remnant of the Tethyan oceanic lithosphere. We performed mineral chemistry and microstructural analyses on five spinel-harzburgite and three spinel-dunite samples from its mantle section which show varying degree of serpentinization. The five harzburgite samples are divided into two types based on the mineral chemistry of olivine (Mg# = 0.92-0.94) and spinel (TiO₂ = 0-0.38 wt%, Al₂O₃ = 8.67-27.46 wt%, Cr# = 0.50-0.81). These data, together with dynamic recrystallization textures, indicate high-temperature (≥ ~1000°C) origin for the peridotites. The first type includes three harzburgites with spinel and olivine chemistry indicating a spreading ridge to Supra-Subduction Zone origin, with A-type olivine Crystallographic Preferred Orientation (CPO) and a transtensional to simple shear regime of fabric formation. The second type consists of two harzburgites with boninitic affinity, showing D- and E-type olivine CPO and a simple shear regime of fabric formation. Mineral chemistry of the three dunites suggests melt-rock interaction and an island arc setting, with two showing A-type and one E-type olivine CPO and a transtensional regime of fabric formation. Transtensional regime inferred from vorticity analysis helps envisage an extensional setting for the lithospheric mantle. Dehydration of subducting oceanic slab, in a simple shear regime, led to hydration and partial melting of the mantle wedge, changing A-type fabric into E-type. Continued slab-pull resulted in further melting, dehydrating the remaining mantle and creating D-type fabric. This study demonstrates formation of replacive dunite from depleted harzburgite owing to melt-rock interaction and transformation of associated olivine CPO.

keywords: Olivine; Crystallographic preferred orientation (CPO); Ophiolite; Himalaya; Ultramafic; Recrystallization

2-20

Geochemistry & Geophysics

Investigation of Submarine Permafrost Conditions in the Canadian Beaufort Sea Using Diving Wave Tomography

Grob, Henrik., Klaeschen, D., Riedel, Michael., Krastel, Sebastian., Duchesne, M. J., Bustamante, Jefferson., Fabien-Ouellet, Gabriel., **Jin, Young Keun.** and **Hong, Jong Kuk.**
Journal of Geophysical Research-Solid Earth. 2025. 130(4).
doi: 10.1029/2024jb029955.

Submarine permafrost in the Canadian Beaufort Sea is relict terrestrial permafrost, which is continuously degrading since the change of thermal conditions induced by a marine transgression that followed the last glaciation. Permafrost degradation has a crucial socio-ecological significance because its thawing can result in geohazards like landslides or an increase in greenhouse gas emissions. These consequences are mostly regulated by the state of ice in permafrost. In this study, we use marine multichannel seismic data to apply a diving wave tomographic inversion on the outer 50 km of the Canadian Beaufort Shelf. Due to the close relationship between seismic velocity and ice content, we are able to infer detailed information about the present submarine permafrost condition. We find a clear variability of permafrost occurrences between the inner and outer Canadian Beaufort Shelf. At the inner shelf, discontinuous ice-bonding permafrost occurs extensively close to the seafloor but is interrupted by taliks. Within the outer similar to 27 km of the shelf, ice-bonding permafrost is absent in the upper sediments and its top has plunged to >200 m below sea level. These findings add new details to the current state of the degrading permafrost. In addition, we observe seismic anisotropy in the frozen permafrost sediments.

keywords:
submarine permafrost; seismic tomography; canadian beaufort sea; seismic anisotropy

2-21

Multidisciplinary Sciences

Late fluid flow in a primitive asteroid revealed by Lu–Hf isotopes in Ryugu

lizuka, Tsuyoshi., Shibuya, Takazo., Hayakawa, Takehito., Yokoyama, Tetsuya., Gautam, Ikshu., Haba, Makiko K., Ito, Kengo T. M., Hibiya, Yuki., Yamaguchi, Akira., Abe, Yoshinari., Aleon, Jerome., Alexander, Conel M. O'D., Amari, Sachiko., Amelin, Yuri., Bajo, Ken-ichi., Bizzarro, Martin., Bouvier, Audrey., Carlson, Richard W., Chaussidon, Marc., Choi, Byeon-Gak., Dauphas, Nicolas., Davis, Andrew M., Di Rocco, Tommaso., Fujiya, Wataru., Fukai, Ryota., Hidaka, Hiroshi., Homma, Hisashi., Huss, Gary R., Ireland, Trevor R., Ishikawa, Akira., Itoh, Shoichi., Kawasaki, Noriyuki., Kita, Noriko T., Kitajima, Koki., Kleine, Thorsten., Komatani, Shintaro., Krot, Alexander N., Liu, Ming-Chang., Masuda, Yuki., Motomura, Kazuko., Moynier, Frederic., Nagashima, Kazuhide., Nakai, Izumi., Nguyen, Ann., Nittler, Larry., Pack, Andreas., **Park, Changkun.** and 40 others.
Nature. 2025. 646(8083).
doi: 10.1038/s41586-025-09483-0.

Carbonaceous asteroids are the source of the most primitive meteorites1 and represent leftover planetesimals that formed from ice and dust in the outer Solar System and may have delivered volatiles to the terrestrial planets2, 3, 4–5. Understanding the aqueous activity of asteroids is key to deciphering their thermal, chemical and orbital evolution, with implications for the origin of water on the terrestrial planets. Analyses of the objects, in particular pristine samples returned from asteroid Ryugu, have provided detailed information on fluid–rock interactions within a few million years after parent–body formation6, 7, 8, 9, 10–11. However, the long–term fate of asteroidal water remains poorly understood. Here we present evidence for fluid flow in a carbonaceous asteroid more than 1 billion years after formation, based on the ¹⁷⁶Lu–¹⁷⁶Hf decay systematics of Ryugu samples, which reflect late lutetium mobilization. Such late fluid flow was probably triggered by an impact that generated heat for ice melting and opened rock fractures for fluid migration. This contrasts the early aqueous activity powered by short–lived radioactive decay, with limited fluid flow and little elemental fractionation12. Our results imply that carbonaceous planetesimals accreted by the terrestrial planets could have retained not only hydrous minerals but also aqueous water, leading to an upwards revision of the inventory of their water delivery by a factor of two to three.

2-22

Geosciences, Multidisciplinary

Low sulfur emissions from 2022 Hunga eruption due to seawater–magma interactions

Wu, Jie., Cronin, Shane J., Brenna, Marco., **Park, Sung–Hyun.** and 16 others.
Nature Geoscience. 2025. 18(6): 518–524.
doi: 10.1038/s41561-025-01691-7.

The explosive January 2022 Hunga submarine eruption in Tonga injected unprecedented water volumes into the upper atmosphere, generating widespread climatic impacts. However, it ejected anomalously little sulfur compared with other eruptions of similar volume. We explain the missing sulfur with volatile budgets calculated from volcanic ash samples spanning the eruption. We show that magma was stored in a weakly stratified reservoir at 2.1 km to >5.6 km depth. Magma rose within <3 min and fragmented at 400–1,000 m below sea level. This preserves microscale chemical mingling including similar to 1 wt% contrasts in magmatic water concentrations. The 11–h eruption released a total of 319 Tg of magmatic water, which is <10% of that derived from magmatic seawater interaction. Comparing magmatic and residual glass sulfur concentrations shows a total release of 9.4 TgS, but >93% of this entered the ocean during submarine magma fragmentation. These results raise the concern that satellite SO2 monitoring underestimates the magma output of submarine explosions and they are probably near invisible in ice–core records, despite their climate influence caused by water injection into the upper atmosphere.

2-23

Marine Geological Survey in the Arctic Ocean Using the Icebreaker ARAON

Hong, Jong Kuk. and **Jin, Young Keun.**
Journal of the Korean Society of Oceanography. 2025. 30(2): 134–148.
doi: 10.7850/jkso.2025.30.2.134

During the glacial period, the Arctic Ocean was a much smaller, enclosed basin disconnected from the Pacific Ocean. Following

the last glaciation, a rapid rise in sea level led to extensive marine transgression, doubling the ocean’s size and significantly altering its seafloor environment. Submarine permafrost, gas hydrates, and methane seepage, primarily distributed along the continental shelf, have undergone gradual changes due to sea–level fluctuations and global warming, contributing to the instability of the seafloor. To systematically investigate these environmental changes, Korea deployed its first icebreaking research vessel, IBRV Araon, built in 2009, into the Arctic Ocean. This review paper presents key findings from seafloor geological investigations conducted in the Arctic Ocean since 2012. Major results include: (1) the formation of various glacial features and depositional records on the continental shelf due to repeated advances and retreats of marine–based ice sheets during the Pleistocene; (2) the first discovery of gas hydrates and widespread bottom–simulating reflectors (BSRs) in the southwestern Chukchi Sea; and (3) the identification of mud volcanoes and extensive submarine permafrost degradation in the Canadian Beaufort Sea, accompanied by seafloor features such as thermokarst, craters, and pingo–like structures. These findings enhance our understanding of the interactions among glaciation, climate change, and seafloor geology, and provide a foundation for future drilling and long–term monitoring aimed at responding to environmental changes in the Arctic region.

keywords:

Arctic ocean; Marine geological survey; Icebreaker araon; Subsea permafrost; Gas hydrate

2-24

Geochemistry & Geophysics

Mineralogical and isotopic constraints on early, high-temperature events and reservoirs recorded in the interior of a Type B Ca–Al-rich inclusion from the reduced CV3 chondrite Vigarano

Han, Jangmi., **Park, Changkun.** and 4 others.
Geochimica Et Cosmochimica Acta. 2025. 404: 25–40.
doi: 10.1016/j.gca.2025.07.020.

A coordinated mineralogical and oxygen and Al–Mg isotopic study of a Type B Ca–Al–rich inclusion (CAI) from the reduced CV3 chondrite Vigarano was carried out using electron microprobe analysis, transmission electron microscopy, and

secondary ion mass spectrometry. This CAI, a once molten igneous object, shows heterogeneous oxygen isotopic compositions among its constituent mineral phases. Spinel is uniformly ¹⁶O–rich with $\Delta^{17}\text{O} \leq -23 \text{ ‰}$. The $\Delta^{17}\text{O}$ values of Al,Ti–diopside in the CAI core range from -11 ‰ to -18 ‰ , which are positively correlated with its TiO₂ contents, whereas diopside in the Wark–Lovering (WL) rim is ¹⁶O–rich with $\Delta^{17}\text{O} = -23 \text{ ‰}$. Melilite in the CAI mantle shows $\Delta^{17}\text{O}$ values $\leq -10 \text{ ‰}$ only when $\text{Å}_{\text{K}15}$ but becomes more ¹⁶O–poor ($\Delta^{17}\text{O} = -3 \text{ ‰}$ to -9 ‰) when $\text{Å}_{\text{K}15}$. These correlated chemical and oxygen isotopic variations were likely established during crystallization of melilite and Al,Ti–diopside from a partial melt, while spinel preserves the original ¹⁶O–rich composition of the CAI precursor. We infer that a partial melt was isotopically evolving from ¹⁶O–rich to ¹⁶O–poor during melilite crystallization, then back to ¹⁶O–rich during Al,Ti–diopside crystallization via exchange with different gas reservoirs of ¹⁶O–poor and ¹⁶O–rich compositions during heating event(s). Our Al–Mg isotopic measurements of the CAI core and mantle define a single isochron with an inferred initial ²⁶Al/²⁷Al ratio of $(4.93 \pm 0.18) \times 10^{-5}$, indistinguishable from that of the WL rim. This indicates that multiple high–temperature events and oxygen isotope exchange with isotopically distinct gas reservoirs occurred rapidly during the CAI formation.

keywords:

Calcium–aluminum–rich inclusions; Solar nebula; Oxygen isotopes; Al–Mg isotopic systematic; Transmission electron microscopy

2-25

Paleontology

Mollusks and Stenothecoides from Cambrian Stage 4 (Ovatoryctocara granulata assemblage) in North Greenland (Laurentia)

Oh, Yeongju., Peel, John S. and **Park, Tae–Yoon S.**
Journal of Paleontology. 2025. 99(5): 1011–1028.
doi: 10.1017/jpa.2025.10156.

The *Ovatoryctocara granulata* Chernysheva, 1962 assemblage is a diverse fossil fauna that is important for global biostratigraphic correlation within Cambrian Series 2, Stage 4. The assemblage includes more than 60 invertebrate species in North Greenland from Freuchen Land to western Peary Land, but systematic documentation of all the fossils from the assemblage remains to be done. Here we expand

on previous work by describing new mollusks and the problematic *Stenothecoides* from this assemblage in North Greenland, mainly from Freuchen Land. The identified taxa include *Stenothecoides* sp., *Capitoconus borealis*, *Dorispira tippik* Peel and Kouchinsky, 2022, *Dorispira* sp., *Ressericonella pipalukae* Oh and Peel, 2024, *Ressericonella?* sp., *Mellopegma georginense* Runnegar and Jell, 1976, *Mellopegma simesi* (MacKinnon, 1985), *Yochelcionella gracilis* Atkins and Peel, 2004, *Eotebenna arctica* Peel, 1989, *Pelagiella* sp., and three helcionelloid species in open nomenclature. These mollusks and stenothecoids facilitate faunal comparisons of North Greenland with Stage 4 to Miaolingian strata from other paleocontinents such as Siberia, Gondwana (Australia), and peri-Gondwana (North China), as well as within Laurentia.

2-26

Paleontology

Negative ontogenetic allometry of cardinal spines in the early Cambrian arthropod *Isoxys olucris* indicates their defensive function

Nielsen, Morten Lunde., **Lee, Mirinae.**, Wilby, Philip R., **Park, Tae-Yoon S.** and 2 others.
Palaeontology. 2025. 68(4).
doi: 10.1111/pala.70017.

The characteristic cardinal spines of *Isoxys*, a cosmopolitan bivalved arthropod, have been focal to understanding its role in Cambrian ecosystems. It has been proposed that the spines had either a hydrodynamic function, to aid buoyancy, or a defensive function, to protect against predators. Here, we demonstrate that the unusually elongated cardinal spines in *Isoxys volucris* (by far the most abundant taxon in the lower Cambrian Sirius Passet Lagerstätte, North Greenland) had a primary defensive function. Spine measurements of 85 specimens show a negative allometry during ontogeny, with the ratio of cardinal spine length to carapace length decreasing from >3.2 to 0.9. Negative allometric growth is inconsistent with a hydrodynamic function since larger carapaces would require spines which are proportionally at least as long (isometry or positive allometry). Instead, the negative allometry provides evidence for a defensive adaptation comparable to that seen in modern lower-trophic organisms, in which elongated spines increase the overall size of juveniles to deter predators. *Isoxys volucris* was the dominant food source for higher-

trophic benthic and pelagic predators in the Sirius Passet biota, as revealed by the gut contents of arthropods, lobopods, palaeoscolecid and stem-chaetognaths. Its long spines therefore indicate similar adaptive responses to extremely high predation pressures in both modern and early Cambrian ecosystems.

keywords:

Isoxys; negative allometry; defensive spines; gut contents; Cambrian food web; Sirius Passet

2-27

Geochemistry & Geophysics

Origin and Evolution of Miocene Basanite to Comendite Lavas at the Mount Overlord Volcanic Field, Northern Victoria Land, Antarctica

Kim, Jihyuk., Kyle, Philip R., **Lee, Mi Jung.**, **Lee, Jong Ik.** and 4 others.
Journal of Petrology. 2025. 66(3).
doi: 10.1093/petrology/egaf014.

Continental alkaline magmatism produces a wide variety of igneous rock types because of varying degrees of partial melting of heterogenous mantle sources, fractional crystallization, and magma contamination during transit through the continental crust. The Mount Overlord Volcanic Field (MOVF) is a continental alkaline volcanic province in northern Victoria Land, Antarctica. Mount Overlord and the associated vents that make up the volcanic field are some of the least-explored volcanic rocks in the western Ross Sea. The MOVF sits within the Transantarctic Mountains, which form the rift shoulder of the extensive West Antarctic Rift System. The compositions of volcanic rocks in the MOVF range widely from basanite to evolved trachyte and comendite with a suite of intermediate rock types. Here we present ⁴⁰Ar/³⁹Ar ages, petrography, and whole-rock and mineral geochemistry to establish the temporal and magmatic evolution of the magmatic system. Volcanic activity occurred from 21.2 to 6.9 Ma, making it one of the longest records of volcanism in the western Ross Sea area. Mount Rittmann, an active volcano that is part of the MOVF, is not discussed here but extends the timing of volcanism of the MOVF into the Holocene. At Mount Overlord and surrounding areas, there were eruptions of lava flows, domes, and pyroclastic rocks. Localized deposits of hyaloclastites formed

by magma-ice interactions provide an insight into former ice levels. Geochemically the MOVF shows a single magma differentiation trend except for Navigator Nunatak lavas which have a potassic affinity rarely seen in northern Victoria Land. Partial melting of an amphibole-bearing mantle lithology at or near the base of the continental lithospheric mantle (CLM) was the main source of the parental basaltic magmas. Polybaric crystal fractionation of the primary basaltic magmas mainly occurred at lower crustal depths and involved fractionation of clinopyroxene, olivine, kaersutite, feldspars, biotite, Fe-Ti oxides, apatite, and sodalite. Crustal assimilation of c. 10% granite harbor igneous complex granitoids was important in the evolution of intermediate composition magmas. Trachyte, phonolite, and comendite magmas stagnated and evolved at shallow crustal depths (c. <8 km). Over 95% crystal fractionation was required to generate the comendites. Extraction of the comendite melt from a felsic crystal mush was an important process. The potassic Navigator Nunatak magma required partial melting of phlogopite-bearing metasomatized CLM. The metasomes had ‘HIMU-like’ or FOZO isotopic compositions that ultimately originated from recycling of materials in the mantle. The MOVF displays a stronger affinity toward FOZO than other northern Victoria Land basaltic rocks. This suggests that the interaction between parental melt and juvenile CLM was limited, which is similar to volcanic rocks from the oceanic Adare Basin seamounts. Our result emphasizes the critical importance of a thick CLM for the genesis of diverse alkaline magma compositions in a continental rift system.

keywords:

Continental alkaline magmatism; geochronology; magma differentiation; mount overlord volcanic field; Antarctica

2-28

Humanities, Multidisciplinary; Chemistry, Analytical; Materials Science, Multidisciplinary; Spectroscopy

Origin of the Harappan Ernestites: Geochemical Insights into Provenance and Fabrication

Mahala, Milan Kumar., Ray, Jyotiranjana S., Kanungo, Alok K., Sree Bhuvan, G. N. S., Chatterjee, Anirban., George, Bivin Geo., **Sorcar, Nilanjana.** and 3 others.
Npj Heritage Science. 2025. 13(1).
doi: 10.1038/s40494-025-02147-2.

Advancements in stone bead technology, particularly in drilling techniques, emerged during the Indus Valley (Harappan) civilization. Long-constricted cylindrical drill bits, made from a unique stone called Ernestite, were a distinctive feature of this culture. The origin of Ernestite remains uncertain, as it has no known natural analog and its synthesis process is poorly understood. This study presents a mineralogical and geochemical investigation of Ernestite stones and drill bits from multiple Harappan and contemporaneous sites in Gujarat, India, to uncover their origin. The ⁸⁷Sr/⁸⁶Sr and ε_{Nd}(0) of the drill bits overlap with those of the Ernestite stones, confirming their genetic relationship. The texture and presence of pseudo-mullite (SiO₂>40wt%) with high Al-Ti-bearing hematite suggest that Ernestites are synthetic, created through a sintering process at ~1100°C. An abundance of sand to silt-sized detrital quartz, along with Fe-Ti-Zr-rich minerals, indicates the use of unevenly powdered sandstones and laterites as raw materials, with geochemical ties to regional sources.

2-29

Geochemistry & Geophysics

Petrology and Geochemistry of Poikilitic Shergottite Northwest Africa 1950: bridging the gap between depleted and intermediate sources in Martian Mantle

Nair, Varsha M., Sarbadhikari, Amit Basu., Bhuvan, G. N. S. Sree., Kumar, T. Vijaya., **Sorcar, Nilanjana.** and 3 others.
Geochimica Et Cosmochimica Acta. 2025. 410: 101–120.
doi: 10.1016/j.gca.2025.09.043.

Martian meteorite Northwest Africa (NWA) 1950 is a poikilitic shergottite whose whole-rock chemical and isotopic composition indicates its origin from an intermediate mantle source. In this study, we report the results of a detailed petrographic, in-situ trace element, and whole-rock Sr-Nd isotopic investigation carried out on NWA 1950 to understand the cause of the apparent absence of the depleted poikilitic shergottites among the Martian meteorites. The sample exhibits distinct poikilitic and non-poikilitic textural domains. The large pyroxene oikocrysts (up to ~2 mm) enclose early-formed olivine and chromite inclusions (chadacrysts) in the poikilitic domain. The non-poikilitic domain comprises olivine,

pyroxene, maskelynite, merrillite, and other late-stage minerals. Pyroxenes exhibit a highly LREE-depleted pattern, and maskelynite shows no evidence of LREE enrichment. Merrillite is characterized by low REE abundance and a slight negative Eu anomaly, resembling those of depleted olivine-phyric shergottites like Tissint. Olivine grains contain abundant melt inclusions in the poikilitic and non-poikilitic domains. Oxygen fugacity values in the poikilitic and non-poikilitic domains are QFM-2.8 and QFM-2.5, respectively. The measured ⁸⁷Sr/⁸⁶Sr and ¹⁴³Nd/¹⁴⁴Nd ratios for NWA 1950 whole-rock are 0.710432 ± 0.000027 and 0.513201 ± 0.000011, respectively. The REE pattern of melt inclusions is depleted, resembling the depleted shergottites, while the whole-rock REE and Sr-Nd isotopic compositions are of intermediate class. This characteristic of the NWA 1950 melt inclusions enables us to establish a genetic linkage between the intermediate and depleted shergottites and to find out the missing link for the depleted poikilitic shergottites. The parent magma of NWA 1950 is more magnesian and less aluminous than that of the enriched poikilitic shergottites in the same manner that depleted olivine-phyric shergottites have more Mg and less Al than their enriched counterparts. Additionally, the modal proportion of pyroxene to plagioclase and REE abundance in merrillite of NWA 1950 closely matches the depleted olivine-phyric shergottites. The observed enrichment in trace elements and the Sr-Nd isotopic compositions cannot be explained by a depleted mantle source, as inferred from the REE patterns of the constituent minerals in NWA 1950. We propose such enrichment to have originated due to the heterogeneity in the shergottite mantle, aided by the entrapped melt pockets within the upper mantle. A mixture of 0.3-1.0 % trapped liquid in the Martian upper mantle with the parent melt can produce the high REE abundance and Sr-Nd isotopic composition of NWA 1950. Longer residence time in the magma chamber and slower cooling rate of the poikilitic shergottites than the extrusive shergottites could have aided the enrichment in the source region. Additionally, this study suggests that care must be taken in classifying the chemical and isotopic characteristics of the poikilitic shergottites in future studies.

keywords:
Poikilitic shergottite; Depleted REEs of melt inclusions; Martian mantle heterogeneity; Residual melt pockets

2-30 **Multidisciplinary Sciences**

Phosphatic stromatoporoid sponges formed reefs ~480 Mya

Jeon, Juwan., Roda, Mar Simonet., Chen, Zhong-Yang., Luo, Cui., Kershaw, Stephen., **Kim, Daeyeong.** and 3 others.
Proceedings of the National Academy of Sciences of the United States of America. 2025. 122(15).
doi: 10.1073/pnas.2426105122.

Stromatoporoid sponges were important reef-builders during the middle Paleozoic, yet their early history and integration into reef ecosystems remain poorly understood. Here, we report *Lophiostroma leizunia* Jeon sp. nov., the oldest known stromatoporoid from upper Tremadocian to lower Floian (~480 My-old) strata of South China. *L. leizunia* formed complex reef structures, playing crucial roles in framework construction and binding other components, including calcimicrobes, lithistid sponges, stalked echinoderms, and *Calathium*. This discovery pushes back the fossil record of stromatoporoids and the reefs that they formed by approximately 20 My, advancing the onset of the Great Ordovician Biodiversification Event in reef evolution. *L. leizunia* unusually constructed its skeleton using fluorapatite—a feature previously unknown in sponges. This establishes Porifera as the first metazoan phylum known to have utilized all three principal biominerals: silica, calcium carbonate, and calcium phosphate. The presence of phosphatic skeletons in this early stromatoporoid expands our understanding of biomineralization capabilities in early animals and suggests that the genetic toolkit for diverse biomineralization strategies may have been present in early sponges. The unique combination of the earliest known reef-building stromatoporoids and their phosphatic skeletal composition provides insights into the evolutionary dynamics of biomineralization and the rise of metazoan-dominated reef ecosystems during a critical period of Earth’s history.

keywords:
Great Ordovician Biodiversification Event; stromatoporoid, sponge; phosphatic skeleton; reef

2-31 **Geosciences, Multidisciplinary**

Pre-Himalayan tectono-metamorphic impresses in the Bajinath klippe, Kumaun Himalaya, NW India: Implications on a veiled saga of Paleoproterozoic-Neoproterozoic crustal evolution and thermal history of the northern Indian cratonic margin

Mukherjee, Sneha., Ghosh, Gautam., **Sorcar, Nilanjana.** and 3 others.
Geological Society of America Bulletin. 2025. 137(1-2): 841-868.
doi: 10.1130/b37719.1.

Rocks of the Lesser Himalayan Sequence are important from a global tectonic perspective as they represent a crucial evolutionary chronicle of the Indian continent from the Paleoproterozoic to the Cenozoic Himalayan orogeny. Eroded remnants of tectonically transported crystalline thrust sheets overlying the Lesser Himalayan metasedimentary zone along the Main Central thrust are represented by the Almora, Bajinath, Askot, and Chiplakot klippen belts in the Kumaun Himalaya, India. In this work, we present the deformation history, geochemistry, and U-Pb zircon-apatite geochronology of the Bajinath klippe rocks and its footwall. Our age and tectonic setting results for the klippe rocks help to illustrate the continental accretion processes that prevailed during Paleoproterozoic-Neoproterozoic time along the northern Indian cratonic margin. Granitoids within the Bajinath klippen yield crystallization ages varying from ca. 1870 Ma to ca. 1850 Ma, while the supracrustal sequence preserves a prominent age signature of ca. 1855 Ma. The metasediments of the Berinag Formation at the klippe footwall yield a detrital age of ca. 1810 Ma. Based on these results and the geochemistry, we infer that the Bajinath klippe rocks bear an affinity with the inner Lesser Himalayan Sequence, and the granitoid magmatism took place within a span of ~20 m.y. (1870-1850 Ma) in an arc setting linked to active subduction along the north Indian continental margin, possibly due to the formation of the Columbia supercontinent during the Paleoproterozoic. Textural and mineralogical data from the amphibolite-facies supracrustals of the Bajinath klippe suggest that the progressive metamorphism (M₁) reached peak at ~580°C and ~8.6 kbar followed by a decompression-dominated retrogression (M_{1R}) down to ~450°C and ~5.8 kbar, possibly through a clockwise pressure-temperature (*P-T*) trajectory that was overprinted by

the Cenozoic reworking (M2 metamorphism?) and deformation (D₂) related to the Himalayan orogeny. Texturally constrained apatite grains from M1 metamorphic domains preserve traces of a Neoproterozoic-age tectonothermal imprint that affected the Lesser Himalayan Sequence rocks, possibly during the assembly of the Gondwana supercontinent.

2-32 **Geosciences, Multidisciplinary**

Quartz microstructures and crystallographic preferred orientation analysis across the Himalayan metamorphic core reveal exhumation through changing taper angle and strain partitioning along discreet fault zones

Sen, Aranya., Roy, Swarnendu., **Kim, Daeyeong.** and Sen, Koushik.
Journal of Structural Geology. 2025. 197.
doi: 10.1016/j.jsg.2025.105446.

The Himalayan metamorphic core in the Bhagirathi Valley of North India comprises three major tectonic zones: the Main Central Thrust zone (MCTz) that separates the Paleoproterozoic Lesser Himalayan Crystalline rocks from the Proterozoic to Cambro-Ordovician Greater Himalayan Sequence; the High Himalayan Discontinuity (HHD) that separates the lower inverted metamorphic sequence from the upper anatectic part of the GHS; and the Jhala Normal Fault (JNF) that marks the northernmost boundary of this metamorphic core. Quartz microstructural analyses across this metamorphic core indicate that dynamic recrystallization at lower temperatures overprinted the high-temperature deformation features, also evident from dominant prism<a> slip in quartz. Strength of quartz crystallographic preferred orientation (CPO) is also highest at these locations. Vorticity analysis suggests simple shear partitioning in the JNF and MCTz, with pure shear in other parts. It is concluded that the exhumation of the Himalayan metamorphic core was facilitated by simple shear along the JNF and MCTz, with thrust propagation south of MCTz compensating for changes in the taper angle of the Himalayan wedge due to activity along the JNF.

keywords:
Quartz; EBSD; Vorticity; Microstructures; Bhagirathi valley; Himalaya

2-33

Geochemistry & Geophysics; Engineering, Electrical & Electronic; Remote Sensing; Imaging Science & Photographic Technology

Reviving Legacy Seismic Data via Machine Learning Technique-Part 2: Estimating 3-D Seismic Volumes From 2-D Seismic Lines With VQ-VAE

Lee, Jun-Woo., **Je Lee, Min.** and 2 others.
IEEE Transactions on Geoscience and Remote Sensing. 2025. 63.
doi: 10.1109/tgrs.2025.3567596.

We propose a machine learning-based method that estimates a 3-D seismic volume from irregularly placed 2-D seismic lines, addressing the challenges regarding the local disturbances contained within 2-D lines (e.g., seismic misties and discrepant seismic characteristics across lines). To overcome these challenges, we employ the vector-quantized variational autoencoder (VQ-VAE) framework, which effectively captures global structures in data. Through appropriate data augmentation processes, the network is trained with diverse samples despite the limited availability of seismic volumes, enhancing its generality for estimating 3-D structures. Specifically, numerous training samples are generated from five seismic volumes with various augmentation methods, including perspective transform along the horizontal axes, horizontal flipping, polarity reversal, and random signal-level perturbations (e.g., smooth gain functions and convolution filters). In addition, a two-stage training process, into which randomly generated convolution filters are incorporated, further strengthens the robustness to local disturbances. We validate and evaluate the trained network on unseen 3-D volumes using L1 and 3-D structural similarity index measure (3D-SSIM) metrics, demonstrated with numerical examples. The validation confirms that: 1) the proposed method successfully reconstructs subsurface geological structures from 2-D lines and 2) random filtering enhances performance for inconsistent (IC) lines. In addition, we test the applicability of the proposed method with actual 2-D lines acquired from the Jeju Basin, which have various line intervals ranging from 0.5 to 4 km. The testing results show that the network effectively manages intervals up to 2 km but struggles to estimate structures beyond straightforward horizontal layers at intervals of 4 km.

keywords:
Three-dimensional displays; Surveys; Geology; Training; Interpolation; Estimation; Volume measurement; Two-dimensional displays; Neural networks; Data augmentation; 2-D line interpolation; 2-D/3-D seismic data; 3-D volume data augmentation; 3-D volume estimation; vector-quantized variational autoencoder (VQ-VAE)

2-34

Structural and Compositional Variations of Feldspar in an Ordinary Chondrite Induced by Shock Metamorphism

Kim, Hyeong-gyu., **Park, Changkun.**, Kim, Eun Jeong., Park, Sun Young., **Kim, Hwayoung.** and Kim, Na Hyun.
Korean Journal of Mineralogy and Petrology. 2025. 38(3): 217-225.

Feldspar is a silicate mineral commonly observed in meteorites, and during shock metamorphism, it undergoes partial or complete amorphization. This characteristic is used as a major indicator of shock metamorphism. In this study, we investigated the formation mechanisms and chemical compositional changes of partially amorphous feldspar in ordinary chondrites. Crystalline and amorphous domains were found to coexist within single feldspar grains. The crystalline domains have well-developed internal fractures, whereas the amorphous domains have glass-like surfaces without fractures and exhibit complete extinction under a polarizing microscope. Raman analysis revealed distinct peaks crystalline feldspar, while amorphous feldspar exhibited broad peaks of full widths at half maximum (FWHM), reflecting structural disorder. Both domains exhibit albite-oligoclase compositions. However, the amorphous domains are characterized by higher potassium (K) and lower sodium (Na) contents relative to the crystalline domains. These results suggest the possibility of elemental redistribution during partial melting and quenching in the meteorite impact process. In addition, unlike sanidine and anorthite, albite shows a narrow melt-crystal coexistence field in the phase diagram, resulting in a relatively limited compositional range compared with other feldspars. This interpretation, however, has limitations because it is based on phase equilibria under ambient pressure rather than the high-pressure conditions of shock metamorphism. Therefore, dynamic high-temperature and high-pressure experiments

and studies of phase equilibria under high-pressure conditions that better reflect shock metamorphism are required in the future.

keywords:
Raman; Feldspar; Ordinary chondrite; Partial amorphization; Partial melting

2-35

Geosciences, Multidisciplinary

Tectonic evolution of the Korean Peninsula: A new paradigm for critical building blocks of East Asia

Park, Tae-Yoon S., Oh, Yeongju., Lee, Mirinae. and Kim, Taehwan.
Earth-Science Reviews. 2025. 262.
doi: 10.1016/j.earscirev.2024.105023.

The Korean Peninsula occupies a critical part of East Asia, and thus understanding its tectonic development has a significant impact on comprehending the crustal evolution of the entire East Asia. However, there is still contention surrounding the formation of the Korean Peninsula during the Permian-Triassic collision of the SinoKorean (North China) Craton (SKC) and the South China Craton (SCC). Various hypotheses have been proposed regarding the tectonic affinity of different parts of the Korean Peninsula, complicating the proper understanding of the tectonic evolution in East Asia. This is partly due to a pre-existing geological framework that has played a pivotal role in the tectonic understanding of the Korean Peninsula, originally suggested during the age of the ‘geosyncline.’ This framework involves the tripartite division of the basement rocks into the Nangrim, Gyeonggi, and Yeongnam “massifs.” Not bound by this pre-existing paradigm, here we provide a new perspective on the tectonic evolution of the Korean Peninsula based on multidisciplinary geological data, including paleontology, sedimentology, petrology, and geochronology. An integrative reinterpretation of the data has led to the recognition of critical insights on the development of the Korean Peninsula: (1) the Paleoproterozoic crystalline rocks of the two Gyeonggi ‘blocks’ were basement rocks of the SKC southern margin that were dragged down by the subduction of the eastern tip of the SCC crust during the Permo-Triassic collision and then exhumed during the Late Triassic extensional regime; (2) continental

core complexes of various sizes developed near the tectonic boundaries during the Late Triassic and Cretaceous extensional regimes, resulting in the formation of coeval small non-marine basins throughout the Korean Peninsula; (3) the Cathaysia Block-affinity rocks in the midwestern part of South Korea were brought up to the surface by the Late Triassic Hongseong Core Complex, and; (4) the Hwanghae-Tae'an Belt around the western coast of the Korean Peninsula was formed by a Late Cretaceous ‘continental crust spreading’ event. Accordingly, a new subdivision of tectonic provinces of the Korean Peninsula is presented, which does not accord with the previous tectonic models that proposed either a simple collision belt running through the peninsula or the entire peninsula belonging to the SKC. We present retrograde reconstructions of the Korean Peninsula, representing the geological components from the Late Cretaceous to Permian, and integrate the results with the framework of the Permo-Triassic collision between the SKC and the SCC. Under the new perspective, geological aspects and events known in the Korean Peninsula can be revisited. Except for the northeastern terranes, the Macheollyeong Block, the Gwanmo Massif, and the Dumangang Belt, the tectonic provinces of the Korean Peninsula, from northwest to southeast, consist of the Nangrim Spread Crustal Region (SCR) (including the Pyeongnam District), Hwanghae District, Imjingang Belt, Western Gyeonggi Block, Central Gyeonggi Block, Okcheon Belt (including the Taebaeksan Complex), and Yeongnam Block. The metasedimentary rocks with the SCC-affinity in the Imjingang Belt and the Okcheon Metamorphic Belt were the Devonian-Carboniferous passive margin sediments and their substratum-forming pre-Devonian rocks in the northern margin of the SCC, which were subducted during the continental collision and exhumed in the Late Triassic. A continental arc system was formed as the SCC approached the SKC in the late Paleozoic, and the late Paleozoic Pyeongan Supergroup was formed in forearc basins developed at the southern margin of the SKC before the continental collision. The supracrustal boundary of the SKC and the SCC runs across the ‘Taebaeksan Complex,’ which is marked by the boundary between the SCC-derived Yeongwol Group and the SKC-derived Taebaek Group and Pyeongan Supergroup. Most importantly, the three renowned orogenies in the Korean Peninsula are redefined. The Songrim Orogeny encompasses the events related to the Permo-Triassic collision between the SKC and the SCC and is subdivided into the Early, Middle, and Late phases. The Early and Middle phases represent the accretionary wedge-induced metamorphism and the main continental collision events, respectively, while the Late Phase is represented by post-collisional exhumation events and core

complex developments. The Jurassic Daebo Orogeny was caused by the flat subduction of the Paleo–Pacific (Izanagi) Plate that formed the widespread Jurassic granitoids across the peninsula, the thrust–fault systems in the Okcheon Belt, and the ductile Honam Shear Zone. The Cretaceous Bulguksa Orogeny represents the extensional regime caused by the rollback of the Paleo–Pacific (Izanagi) Plate, which progressively developed core complexes from northwest to southeast and likely triggered an epeirogeny in the early phase of the orogeny. The new tectonic perspective of the Korean Peninsula will provide a critical new basis for the tectonic understanding of the Korean Peninsula, as well as a new insight into the tectonics of East Asia.

keywords:
Korean Peninsula; East Asia; Sino–Korean Craton; South China Craton; Permian–Triassic collision; continental core complex; Taebaeksan Complex; Songrim Orogeny; Daebo Orogeny; Bulguksa Orogeny

average annual velocities in 2021 and 2018, with magnitudes of 0.86 ± 0.11 m/day and 0.34 ± 0.18 m/day, respectively. The lower velocity in 2018 represents a quiescent phase following the previous surge, whereas the acceleration in 2021 reflects renewed dynamic activity linked to terminus retreat. Overall, glacier velocity declined from 2014 to 2018, increased between 2020 and 2022, and slightly decreased again in 2023. During this period, the glacier terminus experienced alternating annual retreat and advance, resulting in a net retreat of approximately 2.9 km. Terminus fluctuations were identified as important factors influencing annual glacier velocity, showing a lagged response between terminus movement and velocity. Including parameters such as ice thickness and subglacial hydrology in future analyses would further improve understanding of glacier velocity controls.

keywords:
Cossi–corr; Glacier velocity; Nathorstbreen glacier; Glacier terminus fluctuation

section located 2 km to the southeast. The Sesong Formation is composed of five lithofacies of sandstone, shale, packstone to grainstone, hematite–coated grainstone, and lime pebble conglomerate. The renewed lithostratigraphic framework informally divides the formation into three members: the lower member (42 m thick) composed of shale with intermittent carbonate facies in the lower half, and very fine to fine laminated sandstone with minor shale and carbonate facies in the upper half, the middle member (45 m thick) characterized by dominance of bioturbated and massive sandstone facies, and the upper member (27 m thick) with fine laminated and bioturbated sandstones with alternating minor carbonate facies. Correlation with previous studies shows that up to 45–m–thick upper middle member and lower upper member has not been reported in previous studies, which fills the lithostratigraphic gap between the Jikdong and Sagundari sections. We suggest that this newly reported interval might contain previously unrecognized trilobite biozones in the Taebaek Group, corresponding to the *Changshania–Irvingella* and *Maladiodella* Zones in North China (Sino–Korean Craton).

keywords:
Sesong Formation; Taebaek Group; Cambrian; Lithostratigraphy; Biostratigraphy

history, long–term heterogeneity of mantle reservoirs, and volcanism persisting over billions of years. Alteration minerals and hydrogen–isotope compositions document the presence of liquid water in the past and a progressive loss of the water through time. Endogenous organics and hydrous phases reported in some specimens are consistent with formation by water–rock reactions and are presently interpreted as products of abiotic processes. Cosmic–ray exposure ages, combined with impact–ejection modeling, elucidate ejection mechanisms and candidate source craters, providing a crucial bridge between surface geology and meteorite records. The ongoing Mars Sample Return mission is expected to mitigate the principal limitations of the meteorite record—lack of geologic context and sampling bias—and, through integration with meteorite–based results, to enable a higher–fidelity reconstruction of Mars’s geologic evolution.

keywords:
Martian meteorites; classification and origin; geological evolution; cratering and ejection; Mars sample return

2-36

Environmental Sciences; Remote Sensing

Temporal glacier velocity variations and their controlling factors in the Nathorstbreen glacier system, Svalbard

Guha, Supratim. and Kim, Hyun–Cheol.
Egyptian Journal of Remote Sensing and Space Sciences. 2025. 28(4): 737–746.
doi: 10.1016/j.ejrs.2025.11.004.

Temporal variations in glacier velocity are not only essential to understand glacier dynamics but also to predict glacier hazards. Therefore, in the current study, the continuous glacier velocities were estimated from 2014 to 2023 in the Nathorstbreen Glacier System (NGS), Svalbard, where a recent surge event has been observed. Also, the study identified and quantified the factors controlling variations of annual glacier velocity. Using Landsat 8 OLI images, Cossi–corr (Co–registration of Optically Sensed Images and Correlation), an advanced Fourier–based image–matching tool, was utilized to estimate the velocity of the NGS. A multivariate regression analysis was performed to evaluate the influence of temperature, precipitation, snowfall, and terminus fluctuations on annual velocity changes. The results indicate that the NGS exhibited the highest and lowest

2-37

Geosciences, Multidisciplinary

The Sesong Formation (middle Guzhangian to middle Jiangshanian), Taebaek Group revisited and redefined

Ham, Seounghun., Cho, Se Hyun., Kim, So Jeong., Woo, Jusun., Oh, Yeongju., Lee, Mirinae., Park, Tae–Yoon S. and Choh, Suk–Joo.
Geosciences Journal. 2025. 29(2): 167–180.
doi: 10.1007/s12303–025–00020–9.

The Sesong Formation spans from the middle Guzhangian to the middle Jiangshanian in age and is traditionally known to consist mostly of dark gray mudstones with interbedded sandstone and limestone layers. While the formation has been intensively studied in terms of paleontology, the full lithostratigraphy of the formation remains incompletely appreciated. This study reports, for the first time, the complete lithostratigraphy of the Sesong Formation (about 114 m thick) where both the lower and upper boundaries with the underlying Daegi and the overlying Hwajeol Formations occur in a single section. We utilized the TB–17A core drilled in 2017 by Korea Institute of Geoscience and Mineral Resources (KIGAM) at the Hyeoldong, Taebaek, supplemented by an outcrop

2-38

Geosciences, Multidisciplinary

Unlocking Martian geology with Martian meteorites

Park, Changkun.
대한지질학회지. 2025. 61(4): 481–494.
doi: 10.14770/jgsk.2025.040

Martian meteorites are currently the only Martian rocks available on Earth and thus provide key constraints on the planet’s geological evolution. They are classified into shergottites, nakhlites, chassignites, orthopyroxenites, and polymict regolith breccia, each with distinct ages and lithological characteristics that span from the early Martian crust to relatively recent volcanic activity. Their Martian origin has been firmly established through diagnostic indicators such as trapped atmospheric gases, oxygen isotopes, and Mn/Fe ratios. Short–lived radioisotope systems and trace element studies revealed rapid accretion and early differentiation of Mars in Solar System

2-39

Geosciences, Multidisciplinary

Upper mantle scale enrichment of Cenozoic intraplate magmatism in Northeast Asia: He–Sr–Nd–Pb–O isotope geochemistry of the basalts around the Korean peninsula

Kim, Donghwan., Lee, Hyunwoo., Lee, Mi Jung., Park, Changkun. and Rizzo, Andrea Luca.
Gondwana Research. 2025. 137: 349–364.
doi: 10.1016/j.jgr.2024.09.016.

The Earth’s mantle is considered to be geochemically heterogeneous, which is reflected by the diverse compositions of oceanic island basalts (OIB). The mantle enrichment resulting in this is primarily attributed to the influx of recycled crustal materials into the mantle through subduction. Additionally, the sub–continental lithospheric mantle (SCLM) complicates the elucidation of mantle heterogeneity. From this perspective, Northeast Asia, where the Pacific stagnant slab in the mantle transition zone and the SCLM distribution are presented, is the suitable site for examining the upper mantle scale enrichment. Here we report He–Sr–Nd–Pb–O isotope compositions of Cenozoic basalts found around the Korean Peninsula to

illustrate the source lithology and components that caused mantle heterogeneity. Our measured helium isotope ratios ranging from 5.7 to 7.3 R_a ($^3\text{He}/^4\text{He}$ ratio of air, $R_a = 1.39 \times 10^{-6}$) are mostly within the SCLM range ($6.1 \pm 0.9 R_a$) but lower than the mid-ocean ridge basalt range (MORB; $8 \pm 1 R_a$). The Sr–Nd–Pb isotope compositions of the basalts generally display a mixture of depleted MORB mantle (DMM), enriched mantle 1 (EM1), and enriched mantle 2 (EM2) components. In addition, the basalts have $\delta^{18}\text{O}_{\text{olivine}}$ (vs. V–SMOW) values ranging from 4.7 to 5.7 ‰ that deviate from the DMM range ($\delta^{18}\text{O}_{\text{olivine}} = 5.1 \pm 0.2$ ‰). Our isotopic analysis results highlight the role of a pyroxenite source in the metasomatized SCLM in the genesis of basalts, and the low $^3\text{He}/^4\text{He}$ ratios of the basalts indicates a significant contribution of SCLM. Moreover, the delaminated cratonic SCLM and asthenosphere–lithosphere interaction are scenarios for the low $^3\text{He}/^4\text{He}$ ratios. Therefore, we propose that mixing of DMM (high $^3\text{He}/^4\text{He}$ ratio; 7 to 9 R_a) and the metasomatized SCLM (low $^3\text{He}/^4\text{He}$ ratio; 5 to 7 R_a) allowed enrichment within the upper mantle scale for the Cenozoic intraplate magmatism in Northeast Asia.

keywords:
Helium isotopes; Radiogenic isotopes; Oxygen isotopes; Intraplate volcanism; Enriched mantle components

2-40

Chemistry, Analytical

U–Th–total Pb monazite chemical dating protocol: application to Gneiss from Wilson metamorphic complex (WMC), Northern Victoria Land (NVL), Antarctica

Sorcar, Nilanjana., Kim, Daeyeong., Kim, Hwayoung., Lee, Jong Ik. and 2 others.
Journal of Analytical Science and Technology. 2025. 16(1).
doi: 10.1186/s40543-025-00499-9.

The present study introduces a novel protocol for U–Th–total Pb monazite chemical dating using JEOL JXA–8530F field-emission electron microprobe at the Electron Microprobe Laboratory of the Division of Glacier and Earth Sciences, Korea Polar Research Institute (KOPRI), Incheon, Republic of Korea. U–Th–total Pb chemical dating by electron microprobe method is an in-situ technique with potentially higher spatial

resolution. The consistent chemical–chronological data from the well-dated RW1 and COM–1 monazites validate the reliability of the analytical protocol used for U–Th–total Pb chemical age dating of monazite. The new protocol has been applied to quartzofeldspathic biotite/ $\pm$ cordierite gneiss from the Wilson Metamorphic Complex (WMC), Northern Victoria Land (NVL), Antarctica. The application of this method to WMC quartzofeldspathic gneiss has yielded refined age estimates that reveal multiple thermal phases from texturally constrained in-situ monazite age data. Based on new age data, we argue that the thermal history in the WMC occurred in a span of ca. 496–455 Ma with the evidence of inherited older age domain of ca. 515 Ma. These results offer new insights into the geologic history of Northern Victoria Land to improve our understanding of the thermal evolution within the broader context of Antarctic tectonics.

keywords:
Monazite; Chemical dating; Electron microprobe; Wilson metamorphic complex; Northern Victoria Land; Antarctica

2-41

Geochemistry & Geophysics

Zirconium isotope composition indicates s-process depletion in samples returned from asteroid Ryugu

Schonbachler, Maria., Fehr, Manuela A., Yokoyama, Tetsuya., Gautam, Ikshu., Nakanishi, Nao., Abe, Yoshinari., Aleon, Jerome., Alexander, Conel., Amari, Sachiko., Amelin, Yuri., Bajo, Ken-ichi., Bizzarro, Martin., Bouvier, Audrey., Carlson, Richard W., Chaussidon, Marc., Choi, Byeon-Gak., Dauphas, Nicolas., Davis, Andrew M., Di Rocco, Tommaso., Fujiya, Wataru., Fukai, Ryota., Haba, Makiko K., Hibiya, Yuki., Hidaka, Hiroshi., Homma, Hisashi., Hoppe, Peter., Huss, Gary R., Ichida, Kiyohiro., Iizuka, Tsuyoshi., Ireland, Trevor., Ishikawa, Akira., Itoh, Shoichi., Kawasaki, Noriyuki., Kita, Noriko T., Kitajima, Koki., Kleine, Thorsten., Komatani, Shintaro., Krot, Alexander N., Liu, Ming-Chang., Masuda, Yuki., Morita, Mayu., Motomura, Kazuko., Moynier, Frederic., Nakai, Izumi., Nagashima, Kazuhide., Nguyen, Ann., Nittler, Larry., Onose, Morihiko., Pack, Andreas., **Park, Changkun.** and 40 others.
Meteoritics & Planetary Science. 2025. 60(1): 3–16.
doi: 10.1111/maps.14279.

Nucleosynthetic isotope variations are powerful tracers to determine genetic relationships between meteorites and planetary bodies. They can help to link material collected by space missions to known meteorite groups. The Hayabusa 2 mission returned samples from the Cb-type asteroid (162173) Ryugu. The mineralogical, chemical, and isotopic characteristics of these samples show strong similarities to carbonaceous chondrites and in particular CI chondrites. The nucleosynthetic isotope compositions of Ryugu overlap with CI chondrites for several elements (e.g., Cr, Ti, Fe, and Zn). In contrast to these isotopes, which are of predominately supernovae origin, s-process variations in Mo isotope data are similar to those of carbonaceous chondrites, but even more s-process depleted. To further constrain the origin of this depletion and test whether this signature is also present for other s-process elements, we report Zr isotope compositions for three bulk Ryugu samples (A0106, A0106–A0107, C0108) collected from the Hayabusa 2 mission. The data are complemented with that of terrestrial rock reference materials, eucrites, and carbonaceous chondrites. The Ryugu samples are characterized by distinct ^{96}Zr enrichment relative to Earth, indicative of a s-process depletion. Such depletion is also observed for carbonaceous chondrites and eucrites, in line with previous Zr isotope work, but it is more extreme in Ryugu, as observed for Mo isotopes. Since s-process Zr and Mo are coupled in mainstream SiC grains, these distinct s-process variations might be due to SiC grain depletion in the analyzed materials, potentially caused by incomplete sample digestion, because the Ryugu samples were dissolved on a hotplate only to avoid high blank levels for other elements (e.g., Cr). However, local depletion of SiC grains cannot be excluded. An alternative, equally possible scenario is that aqueous alteration redistributed anomalous, s-process-depleted, Zr on a local scale, for example, into Ca-phosphates or phyllosilicates.

Part 03.

Marine Sciences

3-1

A Review of Oceanic Variability in the Amundsen Sea, West Antarctica: Implications of Climate Change

Kim, Tae-wan.
Journal of the Korean Society of Oceanography. 2025. 30(4): 255–273.
doi: 10.7850/jkso.2025.30.4.255.

This study presents a comprehensive review of recent oceanic environmental changes and the variability of ice–shelf basal melting in the Amundsen Sea, West Antarctica, driven by climate change. Owing to its deep trough topography and the persistent influence of the Amundsen Sea Low, the Amundsen Sea is particularly vulnerable to the intrusion of Circumpolar Deep Water onto the continental shelf, resulting in the most rapid rates of ice–shelf melting and glacier retreat worldwide, especially at Pine Island Glacier and Thwaites Glacier. The regional water–mass structure is characterized by Antarctic Surface Water, Winter Water, and Modified Circumpolar Deep Water, and variability in the volume, temperature, and salinity of Circumpolar Deep Water directly regulates ice–shelf basal melting. Understanding the mechanisms of oceanic variability in the Amundsen Sea is therefore essential for reducing uncertainties in projections of West Antarctic Ice Sheet instability and its contribution to global sea–level rise. This variability is not governed by a simple warming trend but is strongly modulated by atmosphere–ocean–sea ice interactions, including wind–driven surface stress and curl associated with sea ice, as well as remote climate modes such as the Southern Annular Mode and El Niño–Southern Oscillation. Therefore, future research should prioritize sustained long–term observations and high–resolution coupled modeling to elucidate the interplay between large–scale climate modes

and anthropogenic forcing. By synthesizing the current state of knowledge through an extensive literature review, this study provides a critical foundation for advancing future research on Antarctic and global climate change.

keywords:

Amundsen sea; Circumpolar deep water; Climate change; Ice shelf melting

3-2 Meteorology & Atmospheric Sciences

Assimilating summer sea ice thickness enhances predictions of Arctic sea ice and surrounding atmosphere within two months

Liu, Anling., Yang, Jing., Bao, Qing., Vitart, Frederic., Liu, Jiping., Liang, Xi., Lu, Mengqian., Kim, Seong-Joong. and 3 others.
Npj Climate and Atmospheric Science. 2025. 8(1).
doi: 10.1038/s41612–025–01050–8.

Subseasonal prediction of Arctic sea ice and associated atmospheric conditions during the melting season remains challenging due to limited understanding of sea ice initial conditions. This study integrates sea ice assimilation into the coupled model FGOALS–f2 using the localized error subspace transform ensemble Kalman filter, and conducts subseasonal predictions starting from August 1st over 2004–2023. Results show that simultaneous assimilation of sea ice concentration (SIC) and thickness (SIT) significantly improves sea ice predictions for up to two months, while assimilating SIC alone primarily benefits one–month lead predictions. SIT assimilation provides added predictive value for surface air temperature (SAT) forecasts beyond SIC assimilation alone, effectively extending the atmospheric influence of sea ice initial conditions to two months. This improvement in SAT predictions is primarily attributed to a more realistic representation of the surface energy budget. These findings highlight the pivotal role of summer SIT assimilation to enhance subseasonal predictions in the Arctic and challenge the conventional view that initial conditions affect only short–term forecasts. This study underscores the necessity for better representation of ice–atmosphere interactions in models and advocates for enhanced observational capabilities for summer SIT to improve subseasonal predictions in the Arctic and surrounding regions.

3-3 Multidisciplinary Sciences

Atlantification advances into the Amerasian Basin of the Arctic Ocean

Polyakov, Igor V., Pnyushkov, Andrey V., Charette, Matthew., Cho, Kyoung-Ho., Jung, Jinyoung., Kipp, Lauren., Muilwijk, Morven., Whitmore, Laura., Yang, Eun Jin. and Yoo, Jaeill.
Science Advances. 2025. 11(8).
doi: 10.1126/sciadv.adq7580.

Atlantification—the northward inflow of anomalous waters and biota from the Atlantic into the polar basins—has wide–ranging climatological ramifications. We present previously unknown observational evidence that the atlantification processes are strengthening in the eastern Eurasian Basin. The primary example is the diminishing sea ice, which is related to a powerful ocean–heat/ice–albedo feedback, which accelerates sea–ice losses. Furthermore, we observe that atlantification is extending far beyond the Lomonosov Ridge into the Makarov Basin of the Arctic Ocean where upper ocean ventilation creates a new and unique ecological environment. The eastern part of the Siberian Arctic Ocean is still strongly stratified, but the atlantification–driven shoaling of warm, salty, and nutrient–rich intermediate waters already has important ecological consequences there. Disentangling the role of atlantification in multiple and complex high–latitude changes should be a priority in future modeling and observational efforts.

3-4 Environmental Sciences; Marine & Freshwater Biology; Toxicology

Biochemical properties and vertical distribution of particulate organic carbon in the northern Chukchi Sea

Lee, Jonghyuck., Yang, Eun Jin., Cho, Kyoung-Ho., Jung, Jinyoung. and 5 others.
Marine Environmental Research. 2025. 210.
doi: 10.1016/j.marenvres.2025.107311.

The vertical dynamics of biopolymeric carbon (BPC) components are essential for understanding their role in the biological pump

and carbon cycling. However, little research has addressed their distribution and transformation across the epipelagic, mesopelagic, and bathypelagic zones, particularly in the northern Chukchi Sea. This study investigated the contributions to particulate organic carbon (POC), reduction rates, and vertical distribution of BPC components, including carbohydrate carbon (CHO–C), protein carbon (PRT–C), and lipid carbon (LIP–C), across the Mendeleev Ridge (MR), Chukchi Basin (CB), and Northwind Basin (NB), along with analyzing potential factors influencing the distribution patterns of BPC components and POC. In all three regions (MR, CB, and NB), LIP–C was the dominant BPC component, exhibiting the highest contribution to POC and the lowest reduction rate as depth increased, highlighting its significant role in carbon cycling and export. In the MR and CB regions, elevated POC concentrations were observed at specific depths, corresponding to high LIP–C levels. These findings indicate that BPC components, particularly LIP–C, play a substantial role in influencing POC distribution in these regions. In contrast, the NB displayed distinct POC distribution, with consistently high concentrations extending from the epipelagic to bathypelagic zones. Unlike the MR and CB, POC distributions in the NB appeared less influenced by autochthonous BPC sources, suggesting additional contributions from external factors such as lateral transport. These findings highlight the pivotal role of BPC components in driving POC dynamics and carbon cycling in the northern Chukchi Sea.

keywords:

Biopolymeric carbon; Lipid carbon; Particulate organic carbon; Biological pump; Arctic; Northern chukchi sea

3-5 Oceanography

Bio-optical properties and radiant heating rates in the borderlands region of the Chukchi Sea: The roles of phytoplankton biomass and sea ice cover

Zhu, Xingyuan., Li, Tao., Cooper, Lee W., Yang, Eun Jin., Jung, Jinyoung., Cho, Kyoung-Ho. and 2 others.
Deep-Sea Research Part I–Oceanographic Research Papers. 2025. 218.
doi: 10.1016/j.dsr.2025.104458.

Hydrographic, irradiance, nutrient and chlorophyll–a

concentration data were collected in the Chukchi Borderlands region of the northern Chukchi Sea 2011 and 2015 during Korean Arctic program research cruises. Goals included investigation of the spatial and temporal variability of optical and radiant heating properties in the water column, with a focus on the roles of phytoplankton and sea ice. The distribution of phytoplankton in the Chukchi Borderlands exhibits significant east–west variations, derived from two distinct water body types: Type–C and Type–M. Type–C water is influenced by the relatively low–nutrient Pacific Summer Water and upper layers of the central Beaufort Gyre, while Type–M water is associated with relatively higher–nutrient waters found in upwelling and shelf regions. In addition, the differences between these two water types are also reflected in their thermohaline properties, sea ice concentration, optical properties, and radiant heating rates. Under conditions of high sea ice concentration, we observed that phytoplankton are concentrated in the upper layers where more light is available, which in turn concentrates radiative energy at the surface. This mechanism partly reduces the impact of sea ice cover and increases radiant heating in early melt season, aiding further sea ice melt. The near–surface temperature maximum (NSTM) T–max is strongly correlated with the radiant heating rate ($R-2 = 0.79$; $p < 0.001$), and the presence of sea ice decreases the heating rate. On balance, as Arctic sea ice continues to decline, we estimate that the heat stored in the NSTM would contribute to melting 35.3 cm thickness of existing sea ice. These findings highlight the crucial roles of phytoplankton and sea ice in the dynamics of Arctic Ocean radiant heating.

keywords:
Arctic; Chukchi sea; Radiant heating rate; Bio–optical properties; Phytoplankton

3-6 Chemistry, Physical

Biotic and abiotic factors controlling isoprene, DMS, and oxygenated volatile organic compounds (VOCs) at the Southern Ocean in the Austral fall

Kim, Saewung., Seco, Roger., Jeong, Daun., Guenther, Alex., Kim, Kitae., Mo, Ahra., Choi, Jung–Ok., Park, Jisoo. and Park, Keyhong.
Faraday Discussions. 2025. 258(0): 40–59.
doi: 10.1039/d4fd00168k.

We present shipborne observations of volatile organic compounds such as dimethylsulfide (DMS), isoprene, acetaldehyde, acetone, and methanol over the Southern Ocean in April and May 2018. During the cruise, we encountered air masses influenced by the open ocean, coastal Antarctica, and sea ice. No direct correlation between oceanographic parameters and ambient distributions of VOCs is found. Nonetheless, the previously reported correlations among the observed VOCs are found in our observed dataset. The statistically meaningful ($R^2 > 0.2$) anti–correlation of DMS with acetone and methanol is consistent with the previous report about biological activities associated with DMS emission and uptake of methanol and acetone. A positive correlation for isoprene and acetaldehyde, notably in the air masses originating from coastal Antarctica, indicates that photolysis of dissolved organic matter (DOM) was the likely source for the compounds when we conducted the observations. In addition, the observed VOCs were often enhanced over the sea ice observations. This can be accounted for by the ventilation processes of the dissolved VOCs under the ice.

3-7

Changes in Ocean Current Characteristics Due to Freshwater Discharge from Fjord Regions

Song, Yun Ji., Woo, Seung–Buhm., Kim, Jong Wook. and Kim, Jung–Hyun.
Journal of Korean Society of Coastal and Ocean Engineers. 2025. 37(4): 93–105.
doi: 10.9765/kscoe.2025.37.4.93.

To investigate how meltwater runoff affects current patterns in the fjord, a high–resolution numerical model was developed for the Kongsfjorden region in 2007 using Finite Volume Community Ocean Model (FVCOM). Compared to previous studies, the model adopted a higher–resolution grid, resulting in improved simulation performance. The results showed strong agreement with observations, effectively capturing the temporal variations in water temperature and salinity driven by tidal fluctuations and seasonal changes. The model successfully reproduced the characteristic high water temperatures associated with the West Spitsbergen Current (WSC) and captured the intensification of bottom currents following runoff

events. The impact of meltwater was quantitatively assessed by comparing simulations with and without the runoff. The results revealed that during the summer (July~August), increased glacier meltwater runoff induces a strong upstream current near the seabed in Kongsfjorden. A rotational circulation forms near the fjord mouth, and the seawater–meltwater mixing at the surface enhances vertical stratification in this area. In contrast, in the absence of meltwater, the rotational current still develops, albeit more weakly, with minimal enhancement of the bottom–layer flow.

keywords:
freshwater runoff; fjord; FVCOM; current pattern

3-8 Chemistry, Multidisciplinary; Oceanography

Comparative assessment of preservation methods for major nutrients in polar seawater

Kim, Mi Seon., Choi, Man Sik. and Rhee, Tae Siek.
Marine Chemistry. 2025. 272.
doi: 10.1016/j.marchem.2025.104546.

Major nutrients–nitrate, phosphate, and silicate–are fundamental building blocks of marine biomass. To understand the flow of material and energy in the ecosystem, it is essential to accurately quantify nutrients concentrations. When shipboard analysis is not possible, seawater samples must be preserved without altering their contents. In this study, we investigated a range of commonly used preservation methods, including filtration, chemical poisoning with HgCl₂, and freezing at –20 degrees C or – 80 degrees C without pre–treatment, all aimed at minimizing biological activities. We also evaluated the effects of sample storage periods and thawing periods required before analysis in freezing treatments to determine their impact on nutrients contents. Using four different statistical methods, we assessed a total of 19 experiments to identify the most effective preservation method. Comparison between filtered and untreated seawater samples showed no detectable effect on the preservation by filtration. Deviations from shipboard measurement were detected in samples stored in a freezer, even at –80 degrees C. On the other hand, the nutrient content in the poisoned samples remained virtually intact. The deficiency in nutrient content observed during prolonged

freezing and thawing or storage in a refrigerator at 4 degrees C, compared to shipboard measurements, aligns with the Redfield relationship reported in the Arctic Ocean, suggesting that biological activities occurred either within brine channels during freezing, during refrigerated storage, or both, likely due to viable cold–adapted microbes. Although our findings are based on polar seawater samples, potential biological activities during storage and post–treatment should be carefully examined in the other oceanic regions.

keywords:
Nutrients preservation; Poisoning; Freezing; Filtration

3-9 Marine & Freshwater Biology; Oceanography

Current State of Ocean Acidification in Surface Waters of the Western Arctic Ocean from 2020 to 2022

Kim, Dongseon., Cho, Sosul., Yang, Eun–Jin., Cho, Kyoung–Ho. and Jung, Jinyoung.
Ocean Science Journal. 2025. 60(2).
doi: 10.1007/s12601–025–00214–0.

The aragonite saturation state (Omega arag) was determined for surface waters of the western Arctic Ocean over 3 years, from 2020 to 2022, to investigate the current state of ocean acidification and to assess the interannual variation in surface Omega arag. In the Chukchi marginal area (CMA), surface Omega arag ranged from 0.97 to 1.86 over 3 years, with an average value of 1.20, indicating near–saturated conditions with respect to aragonite. In the East Siberian marginal area (ESMA), surface Omega arag varied from 0.88 to 1.47, with an average value of 1.12, which was slightly lower than levels in the CMA. The ESMA experienced significant changes in environmental conditions and seawater carbonate chemistry during 2020–2022 compared to 2016–2018. These notable changes in the ESMA during 2020–2022 were attributed to the influence of the Beaufort Gyre. In contrast, the CMA showed little interannual variation in environmental conditions and seawater carbonate chemistry from 2016 to 2022. In the ESMA, the progression of ocean acidification depends on the Arctic Oscillation (AO) state; ocean acidification improves with a positive AO state and worsens when the AO state is negative.

keywords:
Aragonite saturation state; Chukchi Sea; Dissolved inorganic carbon; East Siberian Sea; Ocean acidification; Total alkalinity

3-10 Geochemistry & Geophysics

Dissolved zinc and cadmium isotope systematics in the Amundsen and Weddell coastal Antarctic marginal seas

Tian, Hung-An., van Manen, Mathijs., Eich, Charlotte., Jung, Jinyoung. and 4 others.
Geochimica Et Cosmochimica Acta. 2025. 399: 93–110.
doi: 10.1016/j.gca.2025.04.017.

Coastal Antarctica is experiencing rapid environmental change with potential effects on regional marine trace element biogeochemistry. Here, we investigate the biogeochemistry of two dissolved bioactive trace elements, zinc (Zn) and cadmium (Cd), and their isotope ratios (delta 66Zn and delta 114Cd) in two coastal marginal seas with distinct oceanographic features—the Amundsen Sea with the intrusion of Circumpolar Deep Water (CDW) onto the Antarctic continental shelf, and the Weddell Sea where formation of Antarctic Bottom Water occurs. In the Amundsen Sea, our isotope data show CDW predominantly controls delta 66Zn and delta 114Cd on the continental shelf. This result is consistent with previous concentration-focused studies that suggested only a negligible addition of Zn and Cd from continental sediments and ice shelf meltwater, and other processes (e.g., scavenging) play a limited role in their cycling on the shelf region. In the Weddell Sea, homogeneous delta 66Zn and delta 114Cd within different water masses across the Antarctic Peninsula shelf, while Zn and Cd concentrations increase via physical mixing with deep water masses, suggest a preformed isotope signature on the continental shelf. In surface waters of both regions, delta 114Cd exhibited isotope fractionation linked to biological uptake, with different Rayleigh closed system fractionation factors (alpha = Rbiomass/Rseawater) for regions dominated by haptophytes (0.99930–0.99960) and diatoms (0.99970–0.99995) and we speculate that such differences may be associated with variability between species. In contrast, estimated fractionation factors for Zn in haptophytes (0.99995) and diatoms (0.99980–0.99995) dominated blooms are similar and comparable to reported values in the Southern Ocean (0.99995 +/- 0.00001).

At the intermediate depth (250–1500 m) in the Weddell Sea, significantly lower delta 114Cd in the inner gyre compared to the outer gyre implies Cd regeneration and reduced ventilation. This pattern was not observed for delta 66Zn, likely due to its smaller biological fractionation in the surface. These findings confirm the role of CDW as the main source of Zn and Cd to the Amundsen Sea and the importance of physical mixing in setting global dissolved Zn and Cd distributions during the formation of deep waters in the Weddell Sea, providing insights into the impacts of regional coastal systems on the biogeochemistry of Zn and Cd.

keywords:
GEOTRACES; Trace metals; Isotope compositions; Biogeochemistry

3-11 Microbiology

Distribution of Surface-Layer Prokaryotes in the Western Arctic Ocean: Responses to Pacific Water Inflow and Sea Ice Melting

Vipindas, Puthiya Veettil., Venkatachalam, Siddarthan., Jabir, Thajudeen., Yang, Eun Jin., Cho, Kyoung-Ho., Jung, Jinyoung., Lee, Youngju., Moon, Jong-Kuk. and Jain, Anand.
Environmental Microbiology. 2025. 27(7).
doi: 10.1111/1462-2920.70154.

Here, we evaluated how microbial community composition and functions vary along the path of Pacific water inflow, starting from the Bering Sea via the Chukchi Sea to the central Arctic Ocean. Our findings reveal that the inflow of Pacific water and sea ice melt significantly influence the environmental settings of the western Arctic Ocean, resulting in distinct prokaryotic communities with varied distribution patterns between the open Chukchi Sea and the Ice-covered central Arctic Ocean. The heterotrophic populations reliant on phytoplankton predominated in the Bering Sea and Southern Chukchi Sea, while in the Central Arctic Ocean, chemoautotrophic bacteria and archaea contributed equally with heterotrophic populations adapted to oligotrophic conditions. Although no specific functional genes were universally enriched across the metagenome libraries of prokaryotic communities, the relative abundance of functional genes varied among oceanic sectors. The assembly processes of prokaryotic communities

in the western Arctic Ocean were found to be influenced by both deterministic and stochastic factors, with deterministic processes playing a more significant role. Thus, the ongoing increases in Pacific inflow and sea ice melt could lead to the displacement of native chemoautotrophic and oligotrophic populations in the Arctic Ocean by fast-growing heterotrophic populations better adapted to elevated nutrient concentrations and temperatures.

keywords:
archaea; bacteria; chemolithotrophs; ecology; oligotrophy

3-12 Marine & Freshwater Biology; Oceanography

Enhanced Microbial Respiration in the Open Melt Pond in the Arctic Ocean and its Implications for Carbon Cycles

Min, Jun-Oh., Hyun, Jung-Ho., Kim, Bomina., Jung, Jinyoung., Lee, Sang-Heon. and Kang, Sung-Ho.
Ocean Science Journal. 2025. 60(4).
doi: 10.1007/s12601-025-00237-7.

Sea ice melting driven by climate change-induced warming is continuously increasing in the Arctic Ocean. Although heterotrophic microbes play a pivotal role in biogeochemical processes, the impact of heterotrophic microbial respiration (HMR) on biogeochemical carbon cycles associated with the expansion of melt pond (MP) in the Arctic Ocean is understudied. We investigated variations of HMR across three distinct MP types (i.e., open MP, brackish MP, and closed MP) in the western Arctic Ocean. HMR was significantly higher in open MP ($12.2 \pm 5.64 \text{ mmol O}_2 \text{ m}^{-3} \text{ day}^{-1}$) compared to closed MP ($2.25 \pm 1.96 \text{ mmol O}_2 \text{ m}^{-3} \text{ day}^{-1}$), brackish MP ($2.87 \pm 2.28 \text{ mmol O}_2 \text{ m}^{-3} \text{ day}^{-1}$), and ambient seawater ($4.88 \pm 1.92 \text{ mmol O}_2 \text{ m}^{-3} \text{ day}^{-1}$). A strong correlation between dissolved organic carbon (DOC) and HMR suggests that sea-ice-derived DOC enhances heterotrophic microbial metabolism in open MPs. The prokaryotes carbon demand ($27.8 \pm 26.8 \text{ mmol C m}^{-3} \text{ day}^{-1}$) required to sustain prokaryotes metabolism was greater than the organic carbon produced through primary production (PP; $0.05 \pm 0.02 \text{ mmol C m}^{-3} \text{ day}^{-1}$), suggesting that the remineralization of organic carbon supplied from the sea-ice communities to CO₂ exceeds carbon fixation through PP. The high CO₂ production in the open MPs ($2.35 \text{ Tg C day}^{-1}$), which

is 20 times greater than the CO₂ uptake by the MPs ($0.12 \text{ Tg C day}^{-1}$), suggests that warming-induced expansion of MPs stimulates microbial metabolisms, thereby serving as a positive CO₂ feedback to the atmosphere. Our results provide new insights into carbon cycling driven by microbial responses to MP expansion under Arctic warming.

keywords:
Microbial respiration; Melt pond; CO2; Dissolved organic carbon; Arctic Ocean

3-13

Environmental and Ecosystem Changes in the Western Arctic Ocean: A Research Overview

Yang, Eun Jin.
Journal of the Korean Society of Oceanography. 2025. 30(4): 303–324.
doi: 10.7850/jkso.2025.30.4.303.

The Arctic is experiencing the fastest rate of warming on Earth, leading to the rapid disappearance of sea ice and causing profound impacts on the global climate system, marine environments, and ecosystems. These changes are not merely environmental issues but complex challenges closely linked to climate change, fisheries, Arctic shipping route, resource development, and geopolitics, all of which directly affect global climate stability. This review synthesizes environmental and ecosystem changes in the western Arctic Ocean using multidisciplinary observations from the IBRV ARAON, including long-term field surveys, moorings, sediment traps, eDNA analyses, satellite data, and numerical modeling. The study provides the first evidence that Atlantification has expanded into the East Siberian region, identifying the intrusion of Atlantic-origin water as a key process that can accelerate sea-ice loss. Phytoplankton communities are shifting from diatom-dominated to small flagellate-dominated structures, and both under-ice blooms and subsurface chlorophyll maxima were found to contribute substantially to primary production. Under-ice ecosystems were also shown to play an important role in regulating carbon fluxes. In addition, previously unrecognized biogeochemical anomalies including low-oxygen and highly acidified water masses were identified for the first time in the study. This study demonstrate that increased Atlantic water

inflow, enhanced freshwater inputs, and sea-ice decline are jointly intensifying ocean acidification in this study area. Overall, the findings indicate that the western Arctic Ocean is undergoing a rapid transitional phase in which its physical, chemical, and ecological systems are being transformed simultaneously. Future research should focus on advancing long-term Arctic monitoring systems, strengthening international collaborations, and enhancing data interoperability to establish a robust scientific foundation for prediction and management. Furthermore, intensive year-round observations utilizing Korea's next-generation ice-breaking research vessel will provide critical support for sustainable Arctic Ocean governance and contribute to global climate-change mitigation efforts.

keywords:
Arctic warming; Western Arctic Ocean; Atlantification; Carbon cycle; Ecosystem change

3-14

Marine & Freshwater Biology; Oceanography

Identifying zooplankton fecal pellets from in situ images

Perhirin, Margaux., Vilgrain, Laure., Perrin, Genevieve., **Lalande, Catherine.** and 3 others.
Journal of Plankton Research. 2025. 47(1).
doi: 10.1093/plankt/fbae078.

Zooplankton play a crucial role in the biological carbon pump by producing sinking particles including sloppy feeding by-products, fecal pellets, molts and carcasses. However, quantifying their impact of these particles on the carbon cycle remains difficult. The contribution of fecal pellets to particulate organic carbon export is usually assessed using fecal pellets collected from sediment traps and laboratory studies. Here, we identified 50 771 fecal pellet-like particles distributed across three morphological clusters. These were extracted from 987 236 in situ images of non-living particles collected from Baffin Bay (Arctic Ocean) using the Underwater Vision Profiler (UVP). We associated which taxonomic groups produced the fecal pellets by comparing the UVP images with observations of fecal pellet morphology and length. Our results emphasize the feasibility of quantifying fecal pellets from in situ images and the importance of developing the resolution of imaging tools

that would simultaneously identify smaller fecal pellet-like particles and capture images of large crustacean zooplankton. Using in situ images in identifying fecal pellets will facilitate a better understanding of their dynamics, a more accurate calculation of carbon fluxes, and the representation of fecal pellets in biogeochemical models.

keywords:
zooplankton; fecal pellets; in situ imaging; carbon export; Arctic Ocean

3-15

Environmental Sciences

Impacts of dam construction on mercury methylation and bioaccumulation revealed by stable isotopes

Kim, Young-Gwang., Yoon, Ji Won., Kang, Sujin., Shin, Kyung-Hoon., Hyun, Jung-Ho., Ra, Kongtae., **Kim, Jung-Hyun.** and Kwon, Sae Yun.
Environmental Pollution. 2025. 372.
doi: 10.1016/j.envpol.2025.125970.

Impacts of dam construction on mercury (Hg) sources, biogeochemical cycling, and bioaccumulation were investigated along the west coast of Korea, where large-scale national projects were initiated between 1978 and 1990 to build dam or weir at the interface between rivers and estuaries. Total Hg (THg) and methylmercury (MeHg) concentrations and Hg stable isotopes in estuarine sediment cores sampled downstream of dam/weir reveal 74 f 3% reduction in THg, 536 f 158% increase in MeHg, and shifts in Hg sources from riverine export to wet deposition (precipitation) as revealed by increases in Delta 199Hg (by 0.13 f 0.03‰) and Delta 200Hg (by 0.10 f 0.01‰). Stable carbon isotopes, n-alkanes, and four geochemical pools of Hg extracted from the sediment cores show enhanced proportion of labile (F1; 0.28 f 0.21% points) and organically-bound (F2; 34 f 12% points) Hg fractions and the ratio of marine-based organic matter relative to recalcitrant Hg bound to terrestrial organic matter at the downstream estuary. Dam/weir constructions have significant effects on Hg bioavailability and methylation, by enhancing the proportion of dissolved Hg delivered by precipitation and those subject to efficient assimilation by marine algae and microbial utilization. This is evident by the negative delta 202Hg shifts in the sediment

cores at the depths of MeHg peaks. Cessation of riverine Hg input is manifested by 96% reduction of THg in shellfish and enhanced methylation appears to cause 106% increase in fish THg at the downstream estuarine ecosystem. This study underscores the importance of considering complex and long-term biogeochemical modifications as a part of Environmental Impact Assessments.

keywords:
Environmental impact assessment; River; Estuary; Organic matter; Microbial

3-16

Environmental Sciences; Marine & Freshwater Biology

Influence of oceanic emission and gas transfer velocity on atmospheric dimethyl sulfide distribution over the Southern Ocean

Ju, Jaemin., Mo, Ahra., Park, Keyhong., Zhang, Miming., Yan, Jinpei., **Jung, Jinyoung.,** Emmons, Louisa., **Kim, Joo-Hong., Park, Taewook.** and **Park, Jisoo.**
Marine Pollution Bulletin. 2025. 216.
doi: 10.1016/j.marpolbul.2025.118033.

Oceanic dimethyl sulfide (DMS) is a major source of atmospheric sulfur, particularly significant in the Antarctic region. This study conducted nine sensitivity simulations using the Community Earth System Model version 2, combining three seawater DMS climatological inventories and three gas transfer velocities. The most sensitive changes in atmospheric DMS were simulated over the subpolar region according to the DMS inventories and gas transfer velocities. Seasonal variations in atmospheric DMS peaked during the austral summer, except for the continental region, where the peaks occurred in the austral winter. These simulation results were also compared with ship-borne measurements obtained in March 2018, and generally showed significant consistency under specific temporal and regional conditions. The model indicated that DMS concentrations are strongly influenced by the seawater DMS inventory and gas transfer velocity, with this sensitivity varying considerably across different regions and periods, particularly under intense wind conditions.

keywords:
Dimethyl sulfate (DMS); Air-sea DMS exchange; Community Earth System Model (CESM); Emission inventory; Gas transfer velocity; Antarctica

3-17

Environmental Sciences; Meteorology & Atmospheric Sciences

Insights into the year-round vertical distribution of chlorophyll concentration in high-latitude Arctic Ocean: implications for primary production

Park, Jisoo., Ko, Eunho., Cho, Kyoung-Ho., Jung, Jinyoung., Lee, Youngju., Yoo, Jaeill., Moon, Jong Kuk., Shim, Chorom., Lee, Younjo J., Osinski, Robert. and **Yang, Eun Jin.**
Environmental Research Letters. 2025. 20(10).
doi: 10.1088/1748-9326/adfb90.

Climate-induced rapid changes in the Arctic Ocean, such as decreasing sea ice extent and increasing water temperature, are altering nutrient and light availability, profoundly impacting primary producer growth. However, access to the high-latitude Arctic Ocean is limited, and satellite data are primarily available only during summer, making continuous in-situ data collection challenging. We collected year-round chlorophyll-a (Chl-a) concentration data in high-latitude regions using a mooring system and performed a comparative analysis with reanalysis data. Unlike previous satellite-based studies, which typically rely on surface measurements, we used the annual vertical distribution of Chl-a. These data were applied to the vertically generalized production model to accurately estimate annual primary production. The moored Chl-a concentration data showed that phytoplankton exhibited a typical subsurface chlorophyll maximum (SCM) layer as sea ice retreated in June. Contrary to the gradually deepening SCM distribution predicted by model-based reanalysis data, the SCM layer persisted for approximately 4 months. This indicates that light and nutrient conditions within the SCM layer remained stable, sustaining continuous phytoplankton growth. Annual primary production, reflecting this vertical distribution of Chl-a concentration, was 6.85 gC m-2 yr-1. This exceeded satellite-based estimates by at least two-fold, highlighting the significant underestimation of primary production by satellite approaches. Estimating

primary production while accounting for the vertical distribution of phytoplankton and light is essential for improving ecological models to better understand carbon cycle and food web changes in the Arctic Ocean, with important implications for climate change predictions.

keywords:
Arctic Ocean; primary production; subsurface chlorophyll maximum (SCM); Korean Arctic Mooring System

3-18 Multidisciplinary Sciences

Interannual variability in terrestrial dissolved organic matter advection to the eastern East Siberian Sea under contrasting Beaufort Gyre conditions

Jeon, Mi Hae., Jung, Jinyoung., Son, Juyoung., Cho, Kyoung-Ho. and Yang, Eun Jin.
Scientific Reports. 2025. 15(1).
doi: 10.1038/s41598-025-07732-w.

Recent changes in Arctic Ocean circulation, particularly the weakening of the Beaufort Gyre (BG), have potentially significant implications for biogeochemical cycles. This study investigates how interannual BG variability influences the distribution of river water and terrestrial-derived dissolved organic matter (DOM) in the western Arctic Ocean by comparing observations from two contrasting years: 2019 (maximum BG strength: 0.48 x 10⁻⁶) and 2022 (minimum BG strength: 0.14 x 10⁻⁶). Under these contrasting BG conditions, we identified significant changes in both river water fraction (friver) and terrestrial-derived DOM (characterized by fluorescent DOM; FDOM) in the eastern East Siberian Sea surface waters. Specifically, the friver increased by 37%, while high-molecular-weight terrestrial humic-like FDOM increased by 29% from 2019 to 2022. These increases coincided with enhanced cyclonic circulation over the Eurasian Basin and a weakened anticyclonic BG in 2022, facilitating the eastward expansion of Lena River-influenced surface waters. Our findings demonstrate that BG conditions play a crucial role in controlling the distribution of river water and terrestrial-derived DOM from the Eurasian rivers in the western Arctic Ocean. Continued BG weakening could allow terrestrial DOM to penetrate further into the BG region, potentially altering its biogeochemical cycles and carbon dynamics.

3-19 Geosciences, Multidisciplinary; Oceanography

Organic carbon stocks of the surficial sediments in the territorial waters of Korea

Park, Kwangkyu. and 3 others.
Geo-Marine Letters. 2025. 45(2).
doi: 10.1007/s00367-025-00809-5.

Shallow marine environments, including the continental shelf, are important in the global carbon cycle in which organic carbon is transported from land, produced within the ocean, and buried in sediments. The territorial waters of Korea (Republic of Korea) encompass predominantly shallow continental shelves. This study examined the organic carbon distribution of surficial sediments in the territorial waters of Korea to approximate the carbon stocks in the surficial sediments of the seafloor at a national scale. For the estimation, the reported data (mean grain size (MGS), total organic carbon (TOC) content, and dry bulk density) around the Korean Peninsula were documented and organized to evaluate the potential for carbon sequestration in the territorial waters of Korea. The distribution of the MGS and the TOC content in surficial sediments varied regionally according to the depositional processes, but they exhibited the typical characteristics of marine sediments whose TOC content increased as the MGS decreased. Among the four zones (A, B, C, and D) in the territorial waters of Korea, the estimated total carbon stock was highest (2.27×10⁶ Mg C) in zone A and lowest (1.04×10⁶ Mg C) in zone C, despite zone C having the highest carbon stock per unit area (1.64 Mg C/ha). However, for a precise assessment of long-term carbon stock and sequestration rates, more comprehensive and robust data along with representative sedimentation rates and the vertical profiles of the TOC content are essential at a national scale.

3-20

Phytoplankton Ecology in the Amundsen Sea, West Antarctica

Lee, Youngju.
Journal of the Korean Society of Oceanography. 2025. 30(4): 325-343.
doi: 10.7850/jkso.2025.30.4.325.

The Amundsen Sea in West Antarctica is one of the most rapidly warming regions on Earth, characterized by the rapid thinning of ice shelves and a highly productive coastal ecosystem. However, scientific investigation of this region has been limited due to its inaccessibility and geographic isolation. Since the discovery of the Amundsen Sea Polynya—one of the most productive coastal polynyas in Antarctica—through satellite observations in the early 2000s, the region has attracted substantial international attention and has become the focus of numerous research expeditions. In particular, the Korean icebreaker R/V Araon has conducted multi-year expeditions since 2010, contributing significantly to the understanding of phytoplankton community structure, biomass, primary production, physiological characteristics, and their seasonal and interannual variability. The biomass and community structure of phytoplankton in the Amundsen Sea responded sensitively to changes in the physicochemical environment, and these variations directly impacted biogeochemical cycles and food web structures. This underscores the importance of further research to elucidate the role of phytoplankton as a regulator of ecosystem changes and the carbon cycle under accelerating ocean warming.

keywords:
Phytoplankton; Ecology; Amundsen Sea; Polynya; West Antarctica

3-21 Environmental Sciences

Properties of inflowing Pacific and Atlantic water govern total and methylated mercury profiles in the Arctic Ocean

Eom, Sangwoo., Soerensen, Anne L., Rhee, Tae Siek., Hong, Jong Kuk. and 3 others.
Environmental Pollution. 2025. 374.
doi: 10.1016/j.envpol.2025.126254.

High methylmercury (MeHg) concentrations in Arctic marine biota have been linked to high MeHg uptake driven by shallow MeHg peaks at water depths of 100–300 m in the Arctic Ocean. To understand how the biogeochemical characteristics of each basin affects the distribution of total Hg (THg) and MeHg across the Arctic Ocean, the spatial patterns of THg and MeHg were investigated using data from new transects in

the Beaufort Sea (BS) and previously published Arctic Ocean expeditions covering the Canada Basin and Makarov Basin in the Pacific sector, and Amundsen Basin and Nansen Basin in the Atlantic sector. In the BS, the THg concentration in the polar mixed water increased with salinity (r = 0.87, p < 0.01), which was linked to THg transport from the Chukchi Shelf. Transport of Hg from the Chukchi Shelf also drove elevated THg concentrations in the polar mixed water and halocline water in the Canada Basin and Makarov Basin compared to other Arctic basins. The MeHg concentration in the BS was positively correlated with the biological index in the Pacific summer water (r = 0.86, p < 0.01), demonstrating that intrusion of warm and nutrient-rich Pacific water promotes MeHg production in the BS. In line with this result, chlorophyll-a showed a comparable cross-basin trend to that of MeHg, with the highest values in the Nansen Basin. In the halocline water, MeHg concentrations were highest in the Canada Basin likely due to the largest availability of Hg(II). On the contrary, MeHg concentration was highest in the Nansen Basin in the Atlantic water layer, which could be related to the higher seawater temperature and enhanced biological production. The results of this study underscore the critical role of Pacific and Atlantic inflows in modulating the profiles of THg and MeHg in the Arctic Ocean.

keywords:
Total mercury; Methylmercury; Biological index; Chlorophyll-a; Canada Basin; Pacific water

3-22 Environmental Sciences; Meteorology & Atmospheric Sciences

Reversal of Ross Sea shelf water freshening is linked to a persistent decline in Antarctic sea ice since the mid-2010s

Kim, Taekyun., Choo, Sung-Ho., Moon, Jae-Hong., Jin, Emilia Kyung. and 2 others.
Environmental Research Letters. 2025. 20(11).
doi: 10.1088/1748-9326/ae0f3f.

Since the mid-2010s, a sharp rebound in dense shelf water (DSW) salinity has been observed in the Ross Sea, coinciding with a persistent decline in sea ice around Antarctica. Despite extensive scientific study and significant attention given to these two phenomena due to their potential influence on

Earth’s changing climate, a physical link between them has yet to be established. Here, by examining atmospheric circulation in response to shifts in major climate variability modes before and after these dramatic changes, we showed that a combination of large-scale circulation patterns drove both the decline in Antarctic sea ice and the increase in Ross Sea DSW salinity. After the mid–2010s, climate-driven atmospheric circulation generated anomalous northerly winds across much of the high-latitude Southern Ocean. However, the Ross Sea sector uniquely experienced strengthened southerly flow of cold continental air. Consequently, this process led to enhanced sea ice loss around Antarctica through warmer air advection from the north, yet simultaneously, expanded the Ross Sea polynyas, enhancing sea ice formation and contributing to increased Ross Sea DSW salinity. Our findings, therefore, establish a robust linkage between these two Southern Ocean transitions, highlighting their interdependence driven by large-scale climate modes.

keywords:
Ross Sea; dense shelf water; salinity rebound; polynya expansion; Antarctic sea ice decline; asymmetric wind response

3-23

Meteorology & Atmospheric Sciences; Oceanography

Role of sea ice, stratification, and near-inertial oscillations in shaping the upper Siberian Arctic Ocean currents

Polyakov, Igor V., Pnyushkov, Andrey V., Carmack, Eddy C., Charette, Matthew., **Cho, Kyoung-Ho.**, Dykstra, Steven., Haapala, Jari., **Jung, Jinyoung.**, Kipp, Lauren., **Yang, Eun Jin.** and Molodtsov, Sergey.
Ocean Science. 2025. 21(6): 3105–3122.
doi: 10.5194/os-21-3105-2025.

The Siberian Arctic Ocean (SAO) is the largest integrator and redistributor of Siberian freshwater resources and acts to significantly influence the Arctic climate system. Moreover, the SAO is experiencing some of the most notable climate changes in the Arctic, and advection of anomalous Atlantic–(atlantification) and Pacific–origin (pacification) inflow waters and biota continue to play a major role in reshaping the SAO

in recent decades. In this study, we use a large collection of mooring data to create a coherent picture of the spatiotemporal patterns and variability of currents and shear in the upper SAO during the past decade. Although there was no noticeable trend in the upper SAO’s current speed and shear from 2013 to 2023, their seasonal cycle has significantly strengthened. The cycle reveals a strong relationship between upper ocean currents and their shear with sea ice conditions – particularly during transitional seasons – evidenced by a strong negative correlation (–0.94) between seasonal sea ice concentration and current shear. In the shallow (< 20–30 m) summer surface mixed layer, currents have increased because strong stratification prevents wind energy from propagating into the deeper layers. In this case, strong near-inertial currents account for more than half of the summertime current speed and shear. In the winter, a thicker surface layer is created by deep upper SAO ventilation due to atlantification, which distributes wind energy to far deeper (> 100 m) layers. These findings are critical to understanding the ramifications for mixing and halocline weakening, as well as the rate of atlantification in the region.

3-24

Limnology; Oceanography

Sea ice breakup and nutrient supply regulate the timing and magnitude of algal export over the slopes of the Pacific Arctic region

Lalande, Catherine., Yang, Eun Jin., Ko, Eunho., Park, Jisoo., Jung, Jinyoung., Kim, Jeong-Hyun., Moon, Jong-Kuk. and 2 others.
Limnology and Oceanography. 2025. 70(5): 1329–1344.
doi: 10.1002/lno.70032.

Few in situ measurements are conducted early in the productive season in the Arctic Ocean, making it difficult to accurately assess the impact of the recent decline in sea ice cover on algal fluxes. Since 2017, time-series sediment traps have been deployed to collect sinking particles at two sites in the Pacific Arctic region. Here, we present algal fluxes obtained in the East Siberian Sea (ESS) and in the northern Chukchi Sea (NCS) between August 2017 and November 2022. Despite interruptions in sampling, algal fluxes reflected large spatial and temporal variations in the magnitude and timing of algal blooms and export in the region. In the ESS, peak diatom fluxes >600 million cells m^{–2} d^{–1} in early August 2018 reflected

the occurrence of an unusually large and long-lasting diatom bloom sustained by an episodic inflow of nutrient-rich waters. Diatom fluxes were usually lower in the NCS than in the ESS, reaching a peak flux of >170 million cells m^{–2} d^{–1} in late August 2017. As diatoms consistently contributed to the majority of algal fluxes, their rapid decrease and near absence frequently observed during July or August at both sites reflected low nutrient concentrations in the upper water column leading to a dominance of small algal cells typically retained in upper waters. Overall, whereas nutrient supply influenced the magnitude and duration of the diatom fluxes, sea ice breakup determined the timing of peak diatom export in the Pacific Arctic slope region.

3-25

Geosciences, Multidisciplinary

Sources and Dynamics of Dissolved Organic Carbon in Kongsfjorden: Insights From Radiocarbon Analysis

Oh, Sunmin., Fang, Ling., Kim, Jeonghyun., **Yang, Eun Jin.** and 2 others.
Geophysical Research Letters. 2025. 52(8).
doi: 10.1029/2025gl114917.

The Arctic is undergoing rapid warming, resulting in accelerating glacier melt and release of nutrients, particles, and organic matter into coastal fjord systems. Kongsfjorden, a fjord in Svalbard, serves as a natural laboratory for investigating climate-driven shifts in high-latitude fjord ecosystems and their broader implications for the Arctic. To examine dissolved organic carbon (DOC) sources and cycling in Kongsfjorden, we collected samples of seawater, floating ice, and river water in June 2023 and analyzed ¹⁴C and ¹³C in DOC. Radiocarbon values of DOC (as in Δ¹⁴C) in fjord seawater ranged from –302‰ to –253‰, while values in the Bayelva River were higher, suggesting a contribution of younger, terrigenous DOC. However, stable carbon isotope results suggested rapid removal of riverine DOC after entering the fjord. Additionally, differences in Δ¹⁴C values between the inner and outer fjord reflected varying contributions from surface primary production and glacial meltwater inputs.

keywords:
dissolved organic carbon; radiocarbon; carbon cycle; Kongsfjorden; Svalbard

3-26

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

Spatial Regionalization of the Arctic Ocean Based on Ocean Physical Property

Yoon, Joo-Eun., Park, Jinku. and Kim, Hyun-Cheol.
Remote Sensing. 2025. 17(6).
doi: 10.3390/rs17061065.

The Arctic Ocean has a uniquely complex system associated with tightly coupled ocean–ice–atmosphere–land interactions. The Arctic Ocean is considered to be highly susceptible to global climate change, with the potential for dramatic environmental impacts at both regional and global scales, and its spatial differences particularly have been exacerbated. A comprehensive understanding of Arctic Ocean environmental responses to climate change thus requires classifying the Arctic Ocean into subregions that describe spatial homogeneity of the clusters and heterogeneity between clusters based on ocean physical properties and implementing the regional-scale analysis. In this study, utilizing the long-term optimum interpolation sea surface temperature (SST) datasets for the period 1982–2023, which is one of the essential indicators of physical processes, we applied the K-means clustering algorithm to generate subregions of the Arctic Ocean, reflecting distinct physical characteristics. Using the variance ratio criterion, the optimal number of subregions for spatial clustering was 12. Employing methods such as information mapping and pairwise multi-comparison analysis, we found that the 12 subregions of the Arctic Ocean well represent spatial heterogeneity and homogeneity of physical properties, including sea ice concentration, surface ocean currents, SST, and sea surface salinity. Spatial patterns in SST changes also matched well with the boundaries of clustered subregions. The newly identified physical subregions of the Arctic Ocean will contribute to a more comprehensive understanding of the Arctic Ocean’s environmental response to accelerating climate change.

keywords:
Arctic Ocean; sea surface temperature; ocean physical property; spatial clustering

3-27

Environmental Sciences; Marine & Freshwater Biology; Toxicology

Spatial variations of ascidian diets in a glacial retreated fjord of the West Antarctic Peninsula

Kim, Dong- U., **Ahn, In-Young.**, Gal, Jong-Ku., **Ha, Sun-Yong.** and Khim, Jong Seong.
Marine Environmental Research. 2025. 204.
doi: 10.1016/j.marenvres.2024.106891.

The impacts of glacial retreat on diets of ascidians, one of the filter feeders and a major component of the benthicpelagic energy pathway, remain unclear. We analyzed carbon and nitrogen stable isotopes of four dominant ascidian species and five potential food sources in Marian Cove, a deglaciating fjord in West Antarctica. Microphytobenthos was a major food source for ascidians regardless of proximity to the glacier, but phytoplankton contribution decreased closer to the glacier. Particularly near the glacier, microphytobenthos formed visible bushes on the surface of ascidians providing an easily accessible potential food source. The diet of Molgula pedunculata changed with spatial variations in food sources influenced by glaciers, whereas Cnemidocarpa verrucosa, which exhibits a squirting behavior, showed a consistent diet primarily contributed by microphytobenthos regardless of glacial impact. These results provide necessary information for understanding the impact of climate change-induced glacial retreat on the diet of ascidians, a dominant taxon in the Antarctic coast.

keywords:
Antarctic filter-feeder; Southern ocean ascidian; Diet composition; Glacial retreat; Climate change

3-28

Geosciences, Multidisciplinary

Subsurface Methane Accumulation in the Beaufort Sea Driven by Pelagic Processes: A Mechanistic Modeling Approach

Kwon, Young Shin. and **Rhee, Tae Siek.**
Geophysical Research Letters. 2025. 52(18).
doi: 10.1029/2025gl116717.

Observed subsurface methane (CH₄) maxima in the Arctic Ocean challenge traditional benthic-centered models. Here, we integrate a water-column CH₄ module into a coupled biogeochemical model to investigate methane cycling at contrasting coastal and offshore sites in the Beaufort Sea. Baseline simulations underestimated observed subsurface CH₄ peaks, but introducing additional source terms—including lateral transport, zooplankton fecal methanogenesis, organic carbon decomposition, and methylphosphonate breakdown—substantially improved model performance. Results reveal that distinct processes control CH₄ accumulation across regions: both lateral transport and biological production (via zooplankton) contribute to shelf CH₄ dynamics, with physical transport emerging as the dominant process, while zooplankton fecal pellet production and bacterial activity govern offshore CH₄ accumulation. Seasonal variability is tightly linked to primary production, stratification, and vertical mixing. Our findings underscore the critical role of non-benthic CH₄ sources in shaping Arctic methane distributions, with implications for projecting CH₄ fluxes under future climate change.

keywords:
Arctic Ocean; methane cycling; pelagic methane sources; biogeochemical modeling; benthic-pelagic coupling

3-29

Oceanography

Supply of Aged Organic Carbon on the Arctic Chukchi Sea Slope

Kim, Hojung., Kim, Dongseon., **Yang, Eun Jin.**, **Nam, Seung-II.**, Cho, Sosul., **Cho, Kyoung-Ho.**, **Jung, Jinyoung.** and 3 others.
Journal of Geophysical Research-Oceans. 2025. 130(10).
doi: 10.1029/2025jc022731.

To better understand the carbon cycling dynamics in the Arctic Ocean, which is undergoing rapid declines in sea ice extent and increasing temperatures, we examined sinking particles collected by bottom-tethered sediment traps deployed on the Chukchi Sea slope in the Pacific sector of the Arctic Ocean from 2017 to 2021. Sinking particle flux was high during the summer (June–September) and low during the winter (October–May), reflecting the characteristic seasonal variation in primary production. Additionally, two notable phenomena were

observed: (a) substantial interannual variations in summertime particle flux and (b) a continuous supply of aged carbon throughout the year. The pronounced interannual variations in summertime particle flux were plausibly associated with the timing of sea ice retreat, subsequent ice-free periods, and associated biogeochemical processes. Aged particulate organic carbon, likely supplied by sediment resuspension and lateral transport, accounted for a considerable fraction of total carbon flux throughout the year, as evidenced by depleted radiocarbon isotopic compositions and relatively high contents of lithogenic material.

keywords:
sinking particles; radiocarbon; sediment trap; Arctic Ocean; carbon cycle; lateral transport

3-30

Geosciences, Multidisciplinary; Meteorology & Atmospheric Sciences

The OCEAN ICE mooring compilation: a standardised, pan-Antarctic database of ocean hydrography and current time series

Zhou, Shenjie., Dutrieux, Pierre., Giulivi, Claudia F., Jenkins, Adrian., Silvano, Alessandro., Auckland, Christopher., Abrahamsen, E. Povl., Meredith, Michael., Vankova, Irena., Nicholls, Keith., Davis, Peter E. D., Osterhus, Svein., Gordon, Arnold L., Zappa, Christopher J., Dotto, Tiago S., Scambos, Ted., Gunn, Kathryn L., Rintoul, Stephen R., Aoki, Shigeru., Stevens, Craig., Liu, Chengyan., **Yun, Sukyoung.**, **Kim, Tae-wan.**, **Lee, Won Sang.** and 13 others.
Earth System Science Data. 2025. 17(10): 5693–5706.
doi: 10.5194/essd-17-5693-2025.

Continuous moored time series of temperature, salinity, pressure and current speed and direction are of great importance for understanding the continental shelf and under-ice-shelf dynamics and thermodynamics that govern water mass transformations and ice melting in and around Antarctic marginal seas. In these regions, icebergs and sea ice make ship-based mooring deployment and recovery challenging. Nevertheless, over decades, expeditions around the fringe of Antarctica sporadically deployed and recovered hundreds of moored instruments, including those facilitated through ice shelves boreholes. These datasets tend to be archived

in a wide range of data centres, with, to our knowledge, no clear format standardisation. As a result, systematic analysis of historical mooring time series in the marginal seas is often challenging. Here we present the first version of a standardised pan-Antarctic moored hydrography and current time series compilation, with broad international contributions from data centres, research institutes and individual data owners. The mooring records in this compilation span over five decades, from the 1970s to the 2020s, providing an opportunity for a systematic study of the pan-Antarctic water mass transport and shelf connectivity. As a demonstration of the utility of this compilation, we present spectral analysis of the compiled current velocity time series, which unsurprisingly shows the dominating presence of tidal variability within most records. This component of the variability is fitted using multi-linear regression to tidal frequencies, and the tidal fit is removed from the original time series to leave de-tided variability. Given the limited record durations to months to years, de-tided variability is dominated by synoptic (3–10 d period), intraseasonal (10–80 d) and seasonal (similar to 6 months–1 year) signals. The spatial distribution of the kinetic energy integrated within frequency bands is presented and discussed within respective regional contexts, and future avenues of research are proposed. This data compilation is assembled under the endorsement of Ocean-Cryosphere Exchanges in Antarctica: Impacts on Climate and the Earth System (OCEAN ICE) project (<https://ocean-ice.eu/>, last access: 23 October 2025) funded by the European Commission and UK Research and Innovation. It is available and regularly updated in NetCDF format with the SEANOE database at 10.17882/99922 (Zhou et al., 2024a).

3-31

Meteorology & Atmospheric Sciences

The Responses of Antarctic Sea Ice and Overturning Cells to Meridional Wind Forcing

Song, Hajoon, Choi, Yeonju, Edward W. Doddridge and John Marshall. (관련과제번호 : PE24110)
Journal of Climate. 2025. 38(3): 701–716.
doi: 10.1175/jcli-d-24-0070.1.

Meridional winds over the seasonal ice zone of the Antarctic have undergone changes and likely contributed to sea ice extent variability in recent decades. In this study, using observations and an eddy-resolving channel model of the

Antarctic seasonal ice zone, we investigate the influence of meridional wind changes on the sea ice distribution and document how the underlying ocean might change. We find that southerly wind anomalies in austral winter lead to an increase in sea ice extent by encouraging equatorward sea ice drift. This results in more leads and polynyas, ice production, and buoyancy loss near the coastal region and freshening out in the open ocean near the Antarctic Circumpolar Current. In contrast, summertime southerly wind anomalies reduce sea ice extent due to warming anomalies near the sea ice edge. This is a consequence of enhanced meridional overturning circulation (MOC) triggered by enhanced buoyancy loss through surface heat flux and brine rejection, which brings relatively warm water toward the summertime sea ice edge. A water–mass transformation analysis reveals the increased bottom water formation caused by brine rejection and heat loss in leads and polynyas. Changes in sea ice extent and MOC behave in the opposite way when the sign of the wind anomaly is switched from southerly to northerly. Our study shows that meridional wind anomalies can modify not only the sea ice distribution, extent of polynyas, and air–sea buoyancy fluxes but also the ocean’s MOC and bottom water properties.

keywords:
Sea ice; Southern Ocean; Meridional overturning circulation; Idealized models; Ocean models

3-32

Multidisciplinary Sciences

Unicorn: U-Net for sea ice forecasting with convolutional neural ordinary differential equations

Park, Jaesung., Cho, Yoonseo., Jeon, Jong–June., **Park, Jinku., Kim, Hyun–Cheol.** and Hong, Sungchul.
Scientific Reports. 2025. 15(1).
doi: 10.1038/s41598–025–20097–4.

Sea ice at the North Pole is vital to global climate dynamics. However, accurately forecasting sea ice poses a significant challenge due to the intricate interaction among multiple variables. Leveraging the capability to integrate multiple inputs and powerful performances seamlessly, many studies have turned to neural networks for sea ice forecasting. This paper introduces a novel deep architecture named Unicorn, designed

to forecast weekly sea ice. Our model integrates multiple time series images within its architecture to enhance its forecasting performance. Moreover, we incorporate a bottleneck layer within the U–Net architecture, serving as neural ordinary differential equations with convolutional operations, to capture the spatiotemporal dynamics of latent variables. Through real data analysis with datasets spanning from 1998 to 2021, our proposed model demonstrates significant improvements over state–of–the–art models in the sea ice concentration forecasting task. It achieves an average MAE improvement of 12% compared to benchmark models. Additionally, our method outperforms existing approaches in sea ice extent forecasting, achieving a classification performance improvement of approximately 18%. These experimental results show the superiority of our proposed model. A preprint version of this work is available at this url <https://arxiv.org/abs/2405.03929>.

3-33

Variability in Phytoplankton Community Structure and Primary Productivity in Antarctic Coastal Waters

Ha, Sun–Yong., Min, Jun–Oh., Shim, Chorom. and **Lee, Boyeon.**
Journal of the Korean Society of Oceanography. 2025. 30(3): 160–173.
doi: 10.7850/jkso.2025.30.3.160

The coastal ecosystem of the Western Antarctic Peninsula (WAP) is among the regions most rapidly affected by climate change. Marian Cove, located along the southwestern coast of King George Island in the South Shetland Islands, has recently exhibited pronounced spatiotemporal variability in phytoplankton primary productivity. This review examines the key environmental drivers influencing these changes and explores their linkages to ongoing Antarctic climate change. Recent studies suggest that enhanced glacier melting and freshwater discharge have intensified water column stratification, resulting in low–salinity, high–turbidity conditions in the inner cove. These environmental changes have significantly reduced phytoplankton biomass and primary productivity. In contrast, the outer cove retains clearer water conditions with greater light penetration, supporting considerably higher primary productivity. Wind forcing and

variations in mixed layer depth play pivotal roles in regulating nutrient availability and light conditions, thereby influencing phytoplankton community composition. During late summer, increased freshwater input further strengthens stratification, promoting the dominance of cryptophytes and picoplankton. These shifts in community structure facilitate microzooplankton proliferation and lead to a simplification of the food web, potentially reducing the efficiency of energy transfer across trophic levels. This review provides quantitative evidence that climate–driven environmental changes directly affect phytoplankton productivity, community composition, food web structure, and biogeochemical cycling in Antarctic coastal ecosystems. The findings deliver crucial insights necessary for improving predictive capabilities and developing effective conservation strategies for polar marine ecosystems under rapidly changing climatic conditions.

keywords:
Western Antarctic Peninsula; Phytoplankton; Primary productivity; Climate change

3-34

Oceanography

Wind-Induced Topographic Rossby Waves in the Southwestern Slope of the Chukchi Abyssal Plain

Ku, Ahyoung., Donohue, Kathleen A., Watts, D. Randolph., Kim, Kiduk., Song, Hajin., Jeon, Chanhjung., **Park, Taewook., Cho, Kyoung–Ho.** and 2 others.
Journal of Physical Oceanography. 2025. 55(12): 2335–2347.
doi: 10.1175/jpo–d–25–0006.1.

Near–bottom currents collected over 1 year (August 2021–22) using a current– and pressure–recording inverted echo sounder (CPIES) at a depth of 1060 m showed fluctuations within a frequency band between 2 and 6.5 days near the southwestern slope of the Chukchi Abyssal Plain. The amplitude of the fluctuations was approximately 8 cm s^{–1} on average during the summer months and weakened to approximately 3 cm s^{–1} between February and June 2022. Similar fluctuations were reproduced by the data–assimilated Hybrid Coordinate Ocean Model (HYCOM), confirming that they were bottom intensified. Calculations of the bottom–trapping scale using HYCOM revealed that these fluctuations

could be attributed to topographic Rossby waves (TRWs) with a length scale of approximately 50 km. The spatial distributions of TRWs in HYCOM and ray–tracing results suggest that TRWs likely propagated from the west–southwest. It is suggested that these TRWs were triggered by nonlocal wind stress curl (WSC), 220 km to the west along the continental slope, as the coherence in the TRW frequency band between the TRWs and WSC was significant. The weaker TRW signal from February to June 2022 was related to weaker WSC and higher sea ice concentration in the study area. The stronger TRWs from July to October occurred when the WSC was stronger and the sea ice concentration was lower in the study area. Our findings imply that changes in the Arctic WSC field or a longer sea ice–free season could trigger more energetic and frequent TRWs, observable down to 1000–m depth around the southwestern slope of the Chukchi Abyssal Plain.

keywords:
Ocean; Arctic; Currents; Mesoscale processes; Ocean dynamics; Oceanic waves

Part 04.

Life Sciences

4-1

Food Science & Technology

3-bromo-4-(2-hydroxyethyl)-7-methoxy-2H-chromen-2-one inhibits allergic reactions in IgE-mediated RBL-2H3 cells and a passive cutaneous anaphylaxis mouse model

Kim, Moonsu., Kim, Huiji., Moon, Sun Young., Shin, Seong-Ah., Kim, Minji., Choi, Seyeon., Gwon, Sugeun., **Lee, Jun Hyuck.** and 2 others.
Applied Biological Chemistry. 2025. 68(1).
doi: 10.1186/s13765-025-00979-x.

Allergic reactions occur when the immune system overreacts to generally harmless substances, leading to both acute and chronic diseases, which can be fatal. Mast cells are critical mediators of allergic reactions as they bind allergens and trigger the release of inflammatory mediators. In this study, we investigated the anti-allergic effects of the coumarin derivative 3-bromo-4-(2-hydroxyethyl)-7-methoxy-2H-chromen-2-one in rat basophilic leukemia (RBL)-2H3 cells sensitized to dinitrophenyl (DNP)-immunoglobulin E (IgE) and human serum albumin (HSA). Our results demonstrated that 3-bromo-4-(2-hydroxyethyl)-7-methoxy-2H-chromen-2-one effectively reduces the release of β -hexosaminidase and histamine, inhibiting mast cell degranulation. Additionally, 3-bromo-4-(2-hydroxyethyl)-7-methoxy-2H-chromen-2-one suppressed the production of allergy-related pro-inflammatory cytokines (IL-4, IL-13, and TNF- α) and inhibited key signaling pathways, including MAPK, AKT, and NF- κ B. Furthermore, in a passive cutaneous anaphylaxis (PCA) mouse model, 3-bromo-4-(2-hydroxyethyl)-7-methoxy-2H-chromen-2-one reduced ear edema and Evans blue infiltration, further confirming its anti-allergic effects. Collectively, these findings suggest that 3-bromo-4-(2-hydroxyethyl)-7-methoxy-2H-chromen-2-one is a promising candidate for the development of anti-allergic therapeutics.

keywords:
Allergy; Mast cells; 3-Bromo-4-(2-Hydroxyethyl)-7-Methoxy-2H-Chromen-2-One; Anti-Allergic therapeutics; AKT pathway; MAPK pathway

4-2

Chemistry, Medicinal; Pharmacology & Pharmacy

A CALB-like Cold-Active Lipolytic Enzyme from *Pseudonocardia antarctica*: Expression, Biochemical Characterization, and AlphaFold-Guided Dynamics

Liu, Lixiao., **Do, Hackwon.**, Kim, Jong-Oh., **Lee, Jun Hyuck.** and Kim, Hak Jun.
Marine Drugs. 2025. 23(12).
doi: 10.3390/md23120480.

Cold-active lipolytic enzymes enable low-temperature biocatalysis, but remain underexplored in Antarctic actinomycetes. Here, we report the discovery and first-step characterization of a CALB-like cold-active lipolytic enzyme (PanLip) from *Pseudonocardia antarctica*. Sequence and structure analyses revealed a canonical α/β -hydrolase fold with a conserved Ser-Asp-His triad and short helical elements around the pocket reminiscent of CALB's $\alpha 5/\alpha 10$ lid. Mature PanLip was expressed primarily as inclusion bodies in *E. coli*; an N-terminally truncation (PanLip Δ N) improved solubility and PanLip Δ N was purified by Ni-NTA. Far-UV CD confirmed a folded α/β architecture. PanLip Δ N favored short-chain substrates (p-NPA, $k_{cat}/K_M = 2.4 \times 10^5 \text{ M}^{-1}\text{s}^{-1}$) but also showed measurable hydrolytic activity toward natural triglycerides, consistently with a lipase-family esterase. The enzyme showed an activity optimum near 25°C and pH 8.0. The enzyme tolerated low salt (maximal at 0.1 M NaCl), mild glycerol, and selected organic solvents (notably n-hexane), but was inhibited by high salt, Triton X-100, and SDS. AlphaFold predicted high local confidence for the catalytic core; DALI placed PanLip closest to fungal lipases (AFLB/CALB). Temperature-series MD and CABS-flex indicated enhanced surface breathing and flexible segments adjacent to the active site—including a region topologically matching CALB $\alpha 10$ —supporting a flexibility-assisted access mechanism at low temperature. Structure-based MSAs did not support a cold adaptation role for the reported VDLPGRS motif. Taken together, these findings

position PanLip as a promising cold-active catalyst with CALB-like access control and potential for low-temperature biocatalysis.

keywords:
cold-active lipolytic enzyme; *Pseudonocardia antarctica*; catalytic triad; cold-adaptation

4-3

Chemistry, Medicinal; Pharmacology & Pharmacy

A novel multi-target compound mitigates amyloid plaques, synaptic deficits, and neuroinflammation in Alzheimer's disease models

Lee, Yeongyeong., Han, Sukmin., Lee, Jeongmi., Cho, Yongeun., Kim, Jun-Sik., Jeon, Yeji., Cho, Heewon., Yoo, Heejin., Byun, Yujung., **Kim, Tai Kyoung.**, **Hong, Ju-Mi.**, Kim, Hyunwook., Park, Sang Yoon., **Yim, Joung Han.** and 2 others.
Archives of Pharmacal Research. 2025. 48(7-8): 745-764.
doi: 10.1007/s12272-025-01562-0.

Alzheimer's disease (AD) is characterized by progressive cognitive decline, amyloid plaque accumulation, synaptic dysfunction, and neuroinflammation. This study reports the therapeutic potential of (S)-4-amino-5,5-difluoro-N'-methyl-N'-phenylpentanehydrazide hydrochloride (RA-058HM), a novel compound, in ameliorating these pathological features of AD in the 5xFAD mouse model. RA-058HM was administered orally for 8 weeks, and its multi-target effects – including relief from neuroinflammation, normalization of synaptic transmission, reduction of amyloidogenesis (plaque and soluble oligomers, as well as BACE1 levels), and rescue of cognitive function—were evaluated. To our knowledge, RA-058HM is the first compound to demonstrate simultaneous modulation of these key pathways in the 5xFAD model, highlighting its potential as a comprehensive disease-modifying therapy for AD. Behavioural tests revealed marked improvements in spatial and recognition memory in RA-058HM-treated 5xFAD mice, suggesting a reversal of cognitive deficits. At the molecular level, RA-058HM treatment reduced amyloidogenesis, as evidenced by decreased levels of amyloid precursor protein (APP) and β -secretase (BACE1) in the hippocampus, accompanied by reduced plaque formation,

as detected by Thioflavin-S staining. Furthermore, synaptic transmission was restored to near-normal levels in RA-058HM-treated neurons, indicating that RA-058HM effectively rescues synaptic deficits without altering synaptic protein levels of PSD95 and synaptophysin. In addition, treatment of RA-058HM downregulated hippocampal levels of the NLRP3 inflammasome, TNF- α , and GFAP, suggesting a decrease in neuroinflammatory signaling and a modulation of glial activity. Restoration of mitochondrial motility in hippocampal neurons further suggests that RA-058HM may improve cellular energy dynamics. Collectively, these findings indicate that RA-058HM has multifaceted effects on AD pathology, targeting amyloid accumulation, synaptic transmission, neuroinflammation, and mitochondrial function. This study highlights RA-058HM as a promising candidate for AD therapy and underscores the potential of multi-targeted approaches in addressing the complex mechanisms underlying AD progression.

keywords:
Alzheimer's disease; RA-058HM; BACE1; Synaptic transmission; NLRP3 inflammasome

4-4

Zoology

An integrative description of a new species of marine water bear (Heterotardigrada: Echiniscoididae) from the tidal zone of the east coast of Korea

Kihm, Ji-Hoon., Gašiorek, Piotr., Rho, Hyun Soo., Lee, H., Han, Seungyeop., Kim, J., **Kang, P.**, **Choi, J.**, Jung, W. and **Park, Tae-Yoon S.**
European Zoological Journal. 2025. 92(1): 1383-1398.
doi: 10.1080/24750263.2025.2563736.

Tardigrades, or water bears, are microscopic invertebrates renowned for their extraordinary resilience and cryptic diversity. Their microscopic size, paucity of taxonomically distinctive morphological characters and limited molecular data have caused significant taxonomic deflation. *Echiniscoides*, the most speciose genus in the family Echiniscoididae, also harbours multiple undescribed species. In this study, we describe a new marine tardigrade species, *Echiniscoides testudolapis* sp. nov. collected from barnacles inhabiting the intertidal zone of Uljin, Korea. The new species was characterized

using an integrative taxonomic approach combining detailed morphological, morphometric and molecular analyses, including DIC microscopy, SEM microscopy and molecular phylogenetic reconstructions based on mitochondrial COI sequences. Morphologically, *E. testudolapis* sp. nov. is distinguished by its dorsal cuticular sculpturing in the form of circular discs with central punctations (weakly elevated processes), the presence of sensory organs on all legs (papilliform on legs I–II, IV and spike-like on legs III) and a dominant claw formula of 9,9,9,8. Notably, our COI analyses revealed substantial intraspecific genetic variability, with 20 haplotypes identified among 28 individuals (p-distances=0.1–2.8%). In contrast, the examined nuclear markers exhibited low to no genetic variation (p-distances are 0.05%, 0%, 0.2–0.5% and 0.2–0.4% for 18S, 28S, ITS1 and ITS2, respectively). Single nucleotide polymorphism (SNP) analyses indicated that the observed COI polymorphisms are likely functionally neutral. These findings highlight the value of an integrative taxonomic approach in revealing cryptic diversity and provide new insights into the evolutionary processes and biogeographic patterns shaping marine tardigrade diversity.

keywords:
Barnacles; Echiniscoidea; Heterotardigrada; meiofauna; taxonomy

4-5 Food Science & Technology

Anti-allergic effect of 5,7-dihydroxy-4-methylcoumarin in IgE-mediated RBL-2H3 cells and PCA murine model

Gwon, Sugeun., Shin, Seong-Ah., Kim, Moonsu., Moon, Sun Young., Choi, Seyeon., Kim, Minji., **Lee, Jun Hyuck.** and 2 others.
Applied Biological Chemistry. 2025. 68(1).
doi: 10.1186/s13765-025-00980-4.

Allergy is an immune-mediated disorder characterized by an exaggerated response of the immune system to non-hazardous substances, resulting in allergic symptoms such as rash, itching, and runny nose. Current therapeutic interventions include antihistamines and steroids; however, they induce several side effects. Although 5,7-dihydroxy-4-methylcoumarin, a phytochemical derivative, has been

demonstrated to exhibit antioxidant, anti-apoptotic, and anti-aggregatory effects, its anti-allergic properties and underlying molecular mechanisms remain elusive. Therefore, this study was conducted to investigate the anti-allergic effects of 5,7-dihydroxy-4-methylcoumarin in two experimental models: rat basophilic leukemia-2H3 cells sensitized using dinitrophenyl-specific immunoglobulin E (IgE)/human serum albumin and a passive cutaneous anaphylaxis (PCA) murine model. Our findings demonstrated that 5,7-dihydroxy-4-methylcoumarin reduced the release of histamine and β -hexosaminidase and downregulated the mRNA expression of allergic-inflammatory cytokines, such as interleukin (IL)-4, IL-13, and tumor necrosis factor- α , as well as the inflammatory enzyme cyclooxygenase-2. Furthermore, 5,7-dihydroxy-4-methylcoumarin reduced the phosphorylation of mitogen-activated protein kinases such as extracellular signal-regulated kinase and p38, as well as protein kinase B. In vivo, 5,7-dihydroxy-4-methylcoumarin reduced PCA reaction, as evidenced by reduced Evans blue dye extravasation in IgE-mediated local allergic responses. Collectively, these results suggest that 5,7-dihydroxy-4-methylcoumarin holds promise as a novel candidate for the development of anti-allergic drugs.

keywords:
5,7-Dihydroxy-4-methylcoumarin; Anti-allergy; Passive cutaneous anaphylaxis murine model

4-6 Biotechnology & Applied Microbiology; Microbiology

Anticancer Activity of Benzomalvin Derivatives Isolated from *Penicillium spathulatum* SF7354, a Symbiotic Fungus from *Azorella monantha*

Jeon, Min Seo., Hong, Ju-Mi., Kim, Jaewon., Kim, Jina., Kim, Sojin., Sohn, Jae Hak., Han, Se Jong., Yim, Joung Han. and **Kim, Il-Chan.**
Journal of Microbiology and Biotechnology. 2025. 35.
doi: 10.4014/jmb.2505.05003.

Penicillium spathulatum SF7354 was isolated from the extremophilic plant *Azorella monantha* collected in Chilean Patagonia and investigated for its anticancer potential. Crude extracts of SF7354 exhibited significant cytotoxic activity against multiple human cancer cell lines, with the most

pronounced effect observed in HCT116 cells. Flow cytometry analysis revealed that treatment with the extract induced time-dependent apoptosis and sub-G1 accumulation, indicating activation of programmed cell death. Cell cycle analysis further showed early G0/G1 arrest, followed by a progressive increase in apoptotic populations. Western blot analysis demonstrated notable alterations in PARP and p53 protein levels, suggesting a p53-dependent mechanism of apoptosis. HPLC-based purification of the extract led to the isolation of five benzomalvin derivatives (A–E), all of which exhibited dose- and time-dependent cytotoxicity. These findings suggest that SF7354-derived benzomalvins act through apoptosis-associated mechanisms and represent promising candidates for the development of novel anticancer agents.

keywords:
Patagonia; *Penicillium spathulatum*; anticancer; apoptosis; benzomalvin

4-7 Chemistry, Analytical

Antimicrobial Steroids from Poisonous Mushroom *Gymnopilus orientispectabilis* and Their Molecular Docking Studies

Jung, Bowon., Heo, Eun Jin., Nguyen, Dieu Linh., **Youn, Ui Joung.** and 3 others.
Separations. 2025. 12(2).
doi: 10.3390/separations12020023.

In this study, three fungal steroids (1–3) were isolated from the fruiting bodies of the poisonous mushroom *Gymnopilus orientispectabilis*, based on bioactivity-guided isolation methods. The chemical structures of the isolates (1–3) were determined using NMR spectroscopic methods. Compounds 1–3 exhibited inhibition activity against *E. coli*, and their interactions with several bacterial drug targets were studied via in silico molecular docking, where the lowest binding energies were observed for penicillin binding protein 3 (PBP3) (–62.89, –75.89 and –74.47 kcal/mol, for compounds 1, 2 and 3, respectively). An MD simulation was performed to examine the conformational stability, motion and flexibility of protein-ligand complexes. In conclusion, this study investigates fungal steroids from *G. orientaspectabilis* as potential sources for new antimicrobial agents, encouraging further research to develop novel therapies.

keywords:
Gymnopilus orientispectabilis; fungal steroids; bioactivity-guided isolation; antimicrobial activity; molecular docking; molecular dynamics

4-8 Biochemistry & Molecular Biology; Chemistry, Multidisciplinary

Anti-Neuroinflammatory Effects of Prenylated Indole Alkaloids from the Antarctic Fungus *Aspergillus* sp. Strain SF-7367

Liu, Zhiming., Yoon, Chi-Su., Cao, Thao Quyen., Lee, Hwan., **Kim, Il-Chan., Yim, Joung Han.** and 3 others.
Molecules. 2025. 30(2).
doi: 10.3390/molecules30020294.

Inflammation has always been considered a trigger or consequence of neurodegenerative diseases, and the inhibition of inflammation in the central nervous system can effectively protect nerve cells. Several studies have indicated that various natural products inhibit neuroinflammation. Among these, Antarctic fungal metabolites have pharmacological activities and a developmental value. Therefore, this study aimed to evaluate the anti-neuroinflammatory activity of an Antarctic fungus belonging to *Aspergillus* (strain SF-7367). Secondary metabolites of SF-7367 were isolated using high-performance liquid chromatography followed by validation of their anti-inflammatory effects in lipopolysaccharide-stimulated BV2 microglia and RAW264.7 macrophages. Chemical analysis of metabolites from the fungal strain revealed five known compounds: epideoxybrevianamide E (1), brevianamide V/W (2), brevianamide K (3), brevianamide Q (4), and brevianamide R (5). Among these compounds, brevianamide K showed significant anti-inflammatory activity against both cell types. Results of Western blotting and molecular docking showed that brevianamide K could regulate the activation of nuclear factor kappa-light-chain-enhancer of activated B cell (NF- κ B) signaling. This indicates that brevianamide K present in *Aspergillus* sp. (strain SF-7367) can inhibit inflammatory responses by reducing lipopolysaccharide-induced nuclear translocation of NF- κ B (p65). These findings suggest that *Aspergillus* sp. (strain SF-7367) and brevianamide K are candidate agents for treating neurodegenerative diseases.

keywords:
Antarctic fungi; prenylated indole alkaloid; NF-κB; anti-inflammation; molecular docking

4-9 Microbiology

Arctic lichen *Cladonia borealis*-induced cell death is mediated by p53-independent activation of Caspase-9 and PARP-1 signaling in human colorectal cancer cell lines

Hong, Ju-Mi., Min, Seul Ki., Kim, Kyung Hee., Han, Se Jong., Yim, Joung Han., Kim, Sojin., Kim, Youn-Jung. and Kim, Il-Chan.
Journal of Microbiology. 2025. 63(4).
doi: 10.71150/jm.2412012.

The anti-cancer effects of *Cladonia borealis* (an Arctic lichen) methanol extract (CBME) on human colon carcinoma HCT116 cells were investigated for the first time. The proliferation of the HCT116 cells treated with CBME significantly decreased in a dose-and time-dependent manner. Flow cytometry results indicated that treatment with CBME resulted in significant apoptosis in the HCT116 cells. Furthermore, immunoblotting and qRT-PCR results revealed the expression of apoptosis-related marker genes and indicated a significant down-regulation of the apoptosis regulator B-cell lymphoma expression and upregulation of the cleaved form of poly (ADP-ribose) polymerase as DNA repair and apoptosis regulators and central tumor suppressor p53. Therefore, CBME significantly inhibited cell proliferation by inducing apoptosis via the mitochondrial apoptotic pathway in colon carcinoma cells. Collectively, these data suggested that CBME contained one or more compounds with anti-cancer effects and could be a potential therapeutic agent. Further studies are required to identify candidate compounds and understand the mechanism of action of CBME.

keywords:
apoptosis; arctic lichen *Cladonia borealis*; cancer; human colon carcinoma

4-10 Biotechnology & Applied Microbiology; Microbiology

Bioprospecting Antarctic Microorganisms Investigating *Hymenobacter psoromatis* PAMC26554 for Biochemical Potential

Yamaguchi, Hirotake., Yamada, Ryoichi., Lee, Jun Hyuck. and Oh, Tae-Jin.
Journal of Microbiology and Biotechnology. 2025. 35.
doi: 10.4014/jmb.2412.12010.

Microorganisms from the genus *Hymenobacter* are known for their distinctive traits, yet their secondary metabolite (SM) production has not been thoroughly investigated. In this study, we examined the biosynthetic potential of SMs from *Hymenobacter psoromatis* PAMC26554, which was isolated from Antarctic lichen. In silico analysis identified biosynthetic gene clusters (BGCs) for terpenes, non-ribosomal peptide synthetases (NRPSs), and polyketide synthases (PKSs), indicating the strain's potential for novel SM production. Optimization of culture conditions showed that R2A medium at 15°C supported growth. HPLC analysis revealed phenylacetic acid (PAA) as a notable compound, which was characterized by ESI-MS and NMR, marking the first isolation of PAA from the genus *Hymenobacter*. In addition, bioactivity assays indicated moderate lipase inhibition by PAA, while molecular docking studies revealed stable interactions with the enzyme, demonstrating that hydrogen bonding and pi-pi stacking contribute to its lipase inhibitory activity. In summary, this research highlights the genus *Hymenobacter* as a potential source for secondary metabolite discovery, with PAA exemplifying its unexplored biochemical capabilities.

keywords:
Hymenobacter; secondary metabolites; phenylacetic acid; lipase; lipase inhibition

4-11 Microbiology

Case Study on Shifts in Human Skin Microbiome During Antarctica Expeditions

Lee, Kyu-Chan., Lee, Hanbyul., Kim, Ok-Sun. and 3 others.
Microorganisms. 2025. 13(11).
doi: 10.3390/microorganisms13112491.

The human skin microbiome plays a crucial role in maintaining skin health by acting as a barrier against pathogens and modulating immune regulation. This case study investigates the skin microbiome of two healthy Korean male individuals in their 20s during Antarctic expeditions, focusing on microbial changes, reversion to pre-expedition states, and the influence of environmental and lifestyle factors. Notable microbial alterations were observed, including increases in Pseudomonadota and decreases in Actinomycetota, indicating pronounced microbial shifts in response to harsh environmental factors such as low temperature and humidity. Post-expedition revealed incomplete recovery to pre-expedition states, with Host A showing a higher resilience index, suggesting faster microbial recovery. Correlation analyses revealed associations between microbial changes and environmental factors (e.g., temperature, humidity, atmospheric pressure) as well as lifestyle factors (e.g., sunblock usage, outdoor activities), highlighting complex interactions between host behaviors and microbiome dynamics. Despite the study's limited sample size, these findings offer insights into the adaptability and resilience of the skin microbiome under extreme environments, with potential implications for health management and skincare strategies during isolated and prolonged expeditions.

keywords:
skin microbiome; Antarctic expeditions; environmental and lifestyle factors; microbial diversity; resilience and adaptability

4-12 Chemistry, Applied; Polymer Science

CAZyme analysis and functional characterization of a new GH18 chitin hydrolase from *Gelidibacter salicanalis* PAMC21136

Paudel, Lakshan., Pardhe, Bashu Dev., Han, So-Ra., Lee, Jun Hyuck. and Oh, Tae-Jin.
Carbohydrate Polymer Technologies and Applications. 2025. 10: 100773.
doi: 10.1016/j.carpta.2025.100773.

Gelidibacter salicanalis strains remain poorly understood in terms of their genomic attributes and are rarely reported for the degradation of polysaccharides within the niche. *Gelidibacter salicanalis* PAMC21136, an Antarctic isolate, was sequenced and functionally annotated. 251 genes were classified into the CAZyme families, which includes the highest number of GH family, highlighting peculiarity towards various macro biopolymers. Further, based on domain architecture and multiple sequence alignment, gene belonging to the family18 glycoside hydrolase was identified as chitinase. The gene encoding chitinase (MBJ7879808.1) was successfully cloned and expressed in *Escherichia coli* BL21 cells. MBJ7879808.1 demonstrated activity towards colloidal chitin but there was no detectable activity towards microcrystalline crab shell chitin. Enzyme exhibited an exo-pattern of hydrolysis on both colloidal chitin, and shorter chain GlcNAc oligomers namely [(GlcNAc)₃, (GlcNAc)₄, (GlcNAc)₅, and (GlcNAc)₆] producing GlcNAc as a single final product. Biochemical characterization revealed an optimum activity at 25°C and pH 7.0. Mn²⁺ ions significantly enhanced the activity by 1.7-fold. Turnover number (*K_{cat}*) was 8.6 min⁻¹ and catalytic efficiency (*K_{cat}/K_m*) was 2.0ml/mg/min towards the substrate colloidal chitin. These findings expanded the polysaccharide degradation capability of *Gelidibacter salicanalis* PAMC21136 and highlight the biotechnological potential of the GH18 enzyme towards production of chitooligomers.

keywords:
Antarctic bacteria; Exo-chitinase; CAZyme; GH18; Chitooligomers; N -acetyl D-glucosamine

4-13

Characterization and expression analysis of fatty acid desaturase genes in Arctic *Chlamydomonas* sp. KNM0029C[§]

Jeongha So., Sanghee Kim., Jungeun Lee., Hyunsik Chae., Kitae Kim. and Sung Mi Cho.
Korean Journal of Microbiology. 2025. 61(1): 33-45.
doi: 10.7845/kjm.2025.4117.

Fatty acid desaturases (FADs) play a crucial role in the biosynthesis of polyunsaturated fatty acids (PUFAs), which are essential for maintaining membrane fluidity in

cold environments. This study characterizes and analyzes the expression patterns of FAD genes in the Arctic *Chlamydomonas* sp. KNM 0029C, a psychrophilic microalga with significant potential for biofuel production. Phylogenetic analysis revealed that KNM 0029C is closely related to *C. priscuii* UWO241 belongs to the *Moewusinia* clade, yet distinct from other polar *Chlamydomonas* species, such as ICE-L in the *Monadinia* clade. Transcriptomic analysis identified four major FAD genes—*FAD5*, *FAD6*, *FAD7*, and $\Delta 4FAD$ —all of which are localized in the chloroplast. Notably, *FAD6* was the only ω -6 desaturase detected, as KNM0029C lacks the endoplasmic reticulum-localized *FAD2* gene. Protein sequence analysis revealed that *Chlamydomonas* in *Moewusinia* clade (KNM0029C and UWO 241) exhibit protein sequence distances five times greater than those within Chlorophycean/Trebouxiophycean algae. Expression analysis under variable temperature conditions demonstrated a significant up-regulation of all FAD genes at temperature decrease (8°C to 4° C), indicating their role in PUFA synthesis under cold stress. Interestingly, *FAD5* and *FAD7* exhibited increased expression at temperature increase (8°C to 12°C), suggesting a distinct regulatory mechanism for temperature adaptation. These findings highlight the unique genetic variations of KNM0029C in the *Moewusinia* clade from cold environments and indicate its possibility for improving biofuel production by applying genetic engineering tools.

keywords:
polar *Chlamydomonas*; ω -6 desaturase; fatty acid desaturase; genetic variation

4-14

Characterization of a Potato Soft Rot *Pseudomonas* Strain and Its Potential Threat to Greenland Farmlands

Woo, Sungho., Yim, Jeong Min., Lee, Yung Mi. and Kim, Dockyu.
Research in Plant Disease. 2025. 31(3): 255–262.
doi: 10.5423/RPD.2025.31.3.255

Rapid global warming is causing Arctic permafrost to melt, expanding arable land and potentially exposing dormant soilborne plant pathogens to crops. However, research on

bacterial plant pathogens emerging from these newly available farmlands remains limited. In this study, *Pseudomonas* sp. strain G2-4, isolated from the rhizosphere soil of *Oxyria digyna* in Northern Greenland, was characterized as a potent soft rot pathogen capable of producing black pigment, though its role in pathogenicity remains unclear. G2-4 exhibited strong extracellular protease activity, demonstrated by the formation of clear zones on skim milk agar plates, but showed no cellulolytic and pectinolytic activities. This proteolytic activity suggests a potential mechanism for degrading plant cell wall-associated proteins (structural or signaling proteins), which might be the key mechanism in soft rot pathogenesis by G2-4. The strain induced bacterial soft rot on potato tubers across a temperature range of 5°C to 25°C, with maximal pathogenicity at 15°C. Antibiotic susceptibility testing revealed resistance to four antibiotics ampicillin, cefotaxime, ciprofloxacin, and vancomycin while the wellknown Korean soft rot pathogen *Pectobacterium carotovorum* KACC (Korean Agricultural Culture Collection) 16999 was resistant only to vancomycin. These findings underscore the importance of monitoring potentially harmful plant pathogens emerging from Arctic permafrost due to rapid soil warming.

keywords:
Arctic soil; Global warming; Outbreak; Permafrost thawing; Plant pathogen

4-15 Genetics & Heredity

Characterization of the complete mitochondrial genome and phylogenetic analysis of the Southern giant petrel (*Macronectes giganteus*, Procellariiformes: Procellariidae)

Kim, Jong- U. and Kim, Jeong-Hoon.
Mitochondrial DNA Part B-Resources. 2025. 10(5): 361–365.
doi: 10.1080/23802359.2025.2488026.

The Southern giant petrel (*Macronectes giganteus* (Gmelin, 1789)) is a large seabird widely distributed in the southern oceans. In the present study, the complete mitochondrial genome of *M. giganteus* was sequenced and characterized for the first time. The mitogenome sequence was circular and 20,169bp in length. It contains 13 protein-coding genes (PCGs)

including one cis-slicing gene (ND3), 22 transfer RNA (tRNA) genes, and two ribosomal RNA (rRNA) genes. Furthermore, there was an additional copy of two tRNAs and ND6 due to a 2.9kbp duplication. The total nucleotide composition was 30.84% (A), 30.69% (C), 13.05% (G), and 25.42% (T) with an overall GC content of 43.97%. Phylogenetic analysis of all PCGs in the complete mitogenome confirmed the inclusion of *M. giganteus* within the family Procellariidae. These new mitochondrial genome data will be useful for further studies on the phylogenetics and evolutionary history of the family Procellariidae and genus *Macronectes*.

keywords:
Macronectes giganteus; mitogenome; Procellariidae; Southern giant petrel

4-16 Chemistry, Medicinal; Chemistry, Organic

Chemical Constituents and Antimicrobial Activity of Essential Oil from the Lichen *Ramalina peruviana*

Youn, Ui Joung., Kim, Min Ju. and Han, Se Jong.
Chemistry of Natural Compounds. 2025. 61(5): 1009–1010.
doi: 10.1007/s10600-025-04811-2.

4-17 Plant Sciences; Chemistry, Medicinal

Chemical constituents of *Himantormia lugubris* collected from Antarctica and their PTP1B and α -glucosidase inhibitory activities

Ha, Manh Tuan., Le, Thi Thanh., Lee, Da Yeong., Kim, Chung Sub., Youn, Ui Joung., Kim, Sang Hee. and 2 others.
Phytochemistry Letters. 2025. 66: 91–99.
doi: 10.1016/j.phytol.2025.02.009.

A phytochemical investigation of an Antarctic endemic species [*Himantormia lugubris* (Hue) M. Lamb] led to the isolation and structural elucidation of three new compounds including one lanostane-type triterpenoid (1, himanlugubrol A), one ergostane-type sterol (2, himanlugubrol B), one benzyl

orsellinate derivative (3, himanlugubrin A), along with ten known compounds (4–13). The chemical structures of new compounds were determined using diverse NMR techniques, HRESIMS data analysis, and computational approaches supported by advanced statistics (DP4+). The anti-diabetic potential of all isolated compounds was investigated by evaluating their inhibitory effects on PTP1B and α -glucosidase enzymes. As a result, compound 3 moderately inhibited PTP1B with an IC₅₀ value of 43.86 μ M and significantly inhibited α -glucosidase (IC₅₀ = 73.46 μ M) in comparison to the positive controls, ursolic acid (IC₅₀ = 5.92 μ M) and acarbose (IC₅₀ = 210.11 μ M), respectively. Enzyme kinetic analysis revealed that compound 3 demonstrated noncompetitive inhibition of PTP1B and mixed-type inhibition of α -glucosidase. Additionally, molecular docking results supported these in vitro findings, showing that compound 3 had strong binding affinities for the active sites of both PTP1B and α -glucosidase, indicated by the key H-bond and van der Waals interactions and negative binding energies.

keywords:
Himantormia lugubris; Parmeliaceae; Lanostane-type triterpenoid; Ergostane-type sterol; PTP1B, α -glucosidase

4-18 Environmental Sciences

Climate-driven changes in phytoplankton community structure in the Northern Chukchi and East Siberian Seas, Pacific Arctic Ocean

Lee, Youngju., Cho, Kyoung-Ho., Jung, Jinyoung., Yang, Eun Jin., Moon, Jong Kuk. and Kang, Sung-Ho.
Environmental Research Communications. 2025. 7(9).
doi: 10.1088/2515-7620/ae009c.

The Northern Chukchi and East Siberian Seas, located in the Pacific sector of the Arctic Ocean, are undergoing rapid environmental changes; however, phytoplankton community dynamics in this region remain poorly characterized. Using pigment-based taxonomic analyses from summer surveys conducted between 2015 and 2020, we identified significant interannual and spatial variability in phytoplankton composition. Diatoms generally dominated in the cold saline waters of the western region, while small flagellates were more prevalent in the stratified eastern area. In 2017–2018, surface

phytoplankton biomass in the western area increased in association with elevated nutrient concentrations and enhanced diatom biomass, likely driven by an expansion of Atlantic–origin water. In contrast, diatom dominance in this area declined in both 2019 and 2020, while flagellate groups, including prymnesiophytes on the Chukchi borderlands, became more abundant. These changes coincided with anomalously warm conditions and rapid sea ice retreat in 2019, followed by continued sea ice loss in 2020, and were potentially linked to increased inflow of warm Pacific water. Correlation analyses indicated that environmental factors such as temperature, salinity, sea ice cover, and nutrient concentrations exerted taxon–specific influences on community structure. These results suggest that phytoplankton communities in the Pacific Arctic are responsive to hydrographic changes associated with both atlantification and Pacific warming, with possible implications for carbon export and regional trophic dynamics.

keywords:
Arctic warming; phytoplankton community; Pacific Arctic Ocean; atlantification; diatoms; prymnesiophytes

4-19 Plant Sciences

Comparative Metabolite Profiling of Antarctic and Korean Mosses: Insights into Adaptation Mechanisms of Antarctic Moss Species

Naznin, Marufa., Mahmood, Raisul Awal., Alam, Md Badrul., Shin, Kil Ho., **Min, Kyungwon.**, Lee, Sang–Han., **Lee, Hyoungeok.** and Kim, Sunghwan.
Plants–Basel. 2025. 14(14).
doi: 10.3390/plants14142148.

This study investigates the relationship between secondary metabolites and stress tolerance in moss species, with a specific emphasis on comparing Antarctic and Korean mosses. Analyses of total phenolic content (TPC) and total flavonoid content (TFC) revealed that Antarctic mosses contain these compounds at significantly higher levels compared to the Korean mosses. These findings are consistent with greater antioxidant activities observed in Antarctic mosses through DPPH and ABTS center dot+ radical scavenging assays. In this study, a total of 620 metabolites were identified from the moss samples. The results showed that Antarctic

mosses exhibited a high number and diversity of compounds including terpenoids, flavonoids, lipids, and other classes. Additionally, Antarctic mosses had fewer lipids with carbon chain lengths below 18 and a higher content of unsaturated lipids, indicating adaptations to maintain membrane fluidity under cold stress. The phylogenetic relationships suggested a correlation between metabolite profiles and genetic adaptations between these species. This research highlights the complex biochemical strategies that mosses, particularly those in Antarctic regions, employ to adapt the environmental stressors. The high abundance of secondary metabolites in Antarctic mosses not only serves as a defense mechanism against oxidative stress but also suggests their potential applications in various biotechnological aspects. This study reveals new avenues for exploring the ecological roles and potential uses of these resilient plant species.

keywords:
Antarctic moss; antioxidant; stress response; changes in metabolite profile

4-20 Microbiology

Description of *Qipengyuania profunda* sp. nov., isolated from deep seawater of the Amundsen Sea (Antarctica), and reclassification of *Qipengyuania aerophila* Liu *et al.* 2022 as a later heterotypic synonym of *Qipengyuania pacifica* Tareen *et al.* 2022

Lee, Bo Min., Choi, Jy Young., Lee, Su Yeon., Rho, Ami., **Yun, Sukyoung.**, **Lee, Won Sang.** and 2 others.
International Journal of Systematic and Evolutionary Microbiology. 2025. 75(3).
doi: 10.1099/ijsem.0.006713.

Gram–stain–negative, aerobic, rod–shaped bacterial strains, designated HL–TH1^T and HL–TH5, were isolated from deep seawater (1127m depth) of the Amundsen Sea, Antarctica. Phylogenetic analyses based on the 16S rRNA gene sequence revealed that strains HL–TH1^T and HL–TH5 were members of the genus *Qipengyuania* with close relatives *Qipengyuania aerophila* GH25^T (99.3%), *Qipengyuania pacifica* NZ–96^T (99.3%), *Qipengyuania profundimaris* G39^T (99.1%) and *Qipengyuania citrea* RE35F/1^T (98.8%). The complete genome sequences of strains HL–TH1T and HL–TH5 comprised a

chromosome of 3.2 Mbp and a plasmid of 0.1 Mbp, with DNA G+C content of 64.1%. The whole genome–based comparisons using the average nt identity and digital DNA–DNA hybridization values revealed that both strains belonged to the same genomic species but were clearly discriminated (79.4–85.8% and 21.9–29.3%, respectively) from their close relatives in the genus *Qipengyuania*. Both strains showed optimal growth at 30°C, pH 6.5–7.0 and 1.5–2.5% sea salts. The major fatty acids of both strains were C_{18:1} *ω*6c and/or C_{18:1} *ω*7c (37.8–38.4%), C_{17:1} *ω* 6c (18.1–19.7%) and C_{16:1} *ω*6c and/or C_{16:1} *ω*7c (12.3–16.7%). The major isoprenoid quinone was ubiquinone–10. The polar lipids consisted of diphosphatidylglycerol, phosphatidylglycerol, phosphatidylethanolamine, phosphatidylcholine and two unidentified lipids. Hence, we propose that strains HL–TH1^T and HL–TH5 are assigned to a novel species belonging to the genus *Qipengyuania*, for which the name *Qipengyuania profunda* sp. nov. is proposed. The type strain is HL–TH1^T (=KCCM 90517^T=JCM 36585^T). In addition, *Q. aerophila* GH25^T and *Q. pacifica* NZ–96^T were found to be the same species based on a polyphasic approach. Therefore, we propose the reclassification of *Q. aerophila* as a later heterotypic synonym of *Q. pacifica*.

keywords:
deep sea; heterotypic synonym; new species; *Qipengyuania profunda*; reclassification

4-21 Ecology; Marine & Freshwater Biology

Determining horizontal and vertical distributions of polar cod (*Boreogadus saida*) in the Bering Sea and western Arctic Ocean using traditional sampling and environmental DNA metabarcoding

Gwak, Woo–Seok., **Kim, Jee–Hoon.**, **Cho, Kyoung–Ho.** and **Yang, Eun–Jin.**
Regional Studies in Marine Science. 2025. 91.
doi: 10.1016/j.rsma.2025.104522.

Boreogadus saida, commonly known as polar cod, is a key species in Arctic marine ecosystems that is also an indicator of environmental change. This study examined the spatial distribution of *B. saida*, which typically inhabits circumpolar waters ranging in temperature from –2 to 8°C. Age

classification based on size was performed on fish samples collected using ring nets, frame trawl nets, and hand nets. The results demonstrated that most individuals collected by ring and frame trawl nets in the southern Chukchi Sea (SCS) and East Siberian Sea (ESS) during late July and early August were age–0, while those collected in mid–August were age–1 and age–2. The individuals collected by hand net in the surface of the ESS and the northern Chukchi Sea (NCS) were all in age–1 and age–2 + . Smaller larvae collected in the ESS suggested local spawning grounds. Environmental factors, particularly temperature and prey availability, were found to influence habitat selection. To complement traditional sampling methods, environmental DNA (eDNA) metabarcoding using MiFish primers was conducted at various horizontal and vertical sites across the Bering Sea (BS), Chukchi Sea (CS), and ESS. *B. saida* eDNA was detected from surface waters to a maximum depth of 1804 m at temperatures ranging from –1.6 to 4.4° C, which demonstrated the utility of eDNA for mapping both horizontal and vertical distributions. These findings highlight the value of integrating eDNA metabarcoding with conventional techniques to clarify *B. saida*’s distribution and life history. They also emphasize the broader potential of eDNA monitoring as a sensitive, non–invasive framework for Arctic biodiversity assessment. Taken together, our results underscore not only the current distribution of *B. saida* but also the promise of eDNA as a foundation for long–term, ecosystem–wide monitoring in a rapidly changing Arctic.

keywords:
Polar cod (*Boreogadus saida*); East Siberian Sea; Horizontal and vertical distribution; EDNA metabarcoding; Arctic ichthyoplankton; Biodiversity monitoring

4-22 Microbiology

Draft genome sequence of *Sphingomonassp. G1St437* isolated from the Styx Glacier, Antarctica

Kim, Minkyung., **Lee, Subin.** and **Kim, Ok–Sun.**
Microbiology resource announcements. 2025. 14(9):
e0024625–e0024625.
doi: 10.1128/mra.00246–25.

We present the draft genome of *Sphingomonas* sp. GISt437 isolated from the Styx ice core, Antarctica. The genome of strain GISt437 comprises 3,409,635bp with a GC content of 64.9%, encoding 3,274 genes.

keywords:
Sphingomonas; genomic analysis; Antarctica

4-23 Microbiology

Draft genome sequences of five glacial fungi from Styx Glacier, Antarctica

Kim, Ji Seon., Seo, Chang Wan. and Lim, Young Woon.(관련과제번호 : PE25100)
Microbiology resource announcements. 2025. 14(4): e0117524–e0117524.
doi: 10.1128/mra.01175–24.

We generated four high-quality draft genomes of fungi isolated from Styx Glacier, Antarctica. The genome announcement of these fungal strains offers insights into their evolution and adaptation to extreme glacial environments, as well as their potential biotechnological applications.

keywords:
Antarctica; glacial fungi; whole genome sequence; halotolerance

4-24 Environmental Sciences; Public, Environmental & Occupational Health

Eco-friendly decolorization of synthetic dyes using radiation-induced whole cell biocatalyst with enhanced copper resistance

Jeon, Min Seo. and 8 others.
Environmental Research. 2025. 269.
doi: 10.1016/j.envres.2025.120891.

Toxic and carcinogenic compounds, such as synthetic dyes and polyphenols, were widely employed and released as

pollutants in a variety of industries, including textiles, food, and cosmetics. Biological oxidation process that used oxidizing enzymes to breakdown pollutant compounds were environmentally favorable. However, due to the cell toxicity of metal ions supplements used for the biosynthesis of oxidizing enzymes like laccase, their efficient application for biological degradation is limited. In this study, we aimed to boost laccase activity by introducing high copper resistance into whole-cell biocatalysts through irradiation-based accelerated evolution. *Bacillus velezensis* MBLB0692, a laccase producing bacterium, was employed as model strain that exhibited severe sensitivity under 10 mM copper. The selected Cu-resistant mutants not only overcame growth inhibition, but also increased laccase activity by 2.6-fold. The qRT-PCR analysis confirmed that mutants showed significant change in gene expressions related to laccase generation and copper-related functions. Furthermore, dye decolorization assays showed that mutants degrade synthetic dyes more efficiently under high copper conditions. The varying decolorization efficiencies across dyes were attributed to differences in dye structure and the potential influence of copper on enzyme activity. Collectively, these findings emphasize the interaction between copper concentration and laccase activity, and present implications for environmental bioremediation.

keywords:
Bacillus velezensis; Laccase; Dye decolorization; Copper-resistance; Gamma radiation-induced mutant

4-25

Environmental Adaptations through Comparative Morphology of Internal Organs in Antarctic and Temperate Fishes

Yoo, Young-Ji., Kang, Tae-Seok., Kim, Jin-Hyoung. and Gwak, Woo-Seok.
Korean Journal of Ichthyology. 2025. 37(4): 292–299.
doi: 10.35399/ISK.37.4.10.

This study investigates the environmental adaptations of two Antarctic icefishes, *Chaenocephalus aceratus* and *Champsocephalus gunnari*, through a comparative analysis of the internal organ morphology with temperate fish species, *Chelidonichthys spinosus* and *Hexagrammos otakii*, inhabiting

Korean coastal waters. The Southern Ocean is characterized by extreme cold, high dissolved oxygen, and seasonal sea ice, and the Antarctic fishes adapted to such conditions exhibited morphological features that enable efficient oxygen circulation, including colorless blood, well-developed pectoral fins, large hearts, and wide blood vessels. Morphometric analysis revealed that Antarctic fishes possess jaw structures adapted for engulfing pelagic prey such as krill, as indicated by their low protrusion coefficients and low-density. Furthermore, vertebral density measurements demonstrated lower skeletal density in Antarctic fish, which facilitated buoyancy regulation in midwater environments. In contrast, temperate species displayed higher skeletal density and smaller cardiac indices, indicating distinct strategies for circulation and buoyancy suited to their respective climatic conditions. Although the study was limited to a single specimen per species due to the logistical constraints of Antarctic sampling, this study provides valuable preliminary insights into the morphological and physiological adaptations of Antarctic fishes. These results may serve as foundational data for future research into the evolutionary mechanisms underlying cold environment adaptation in marine fishes.

keywords:
Antarctic fish; internal organ morphology; cardiosomatic index; vertebral density; buoyancy adaptation; circulatory system

4-26 Multidisciplinary Sciences

Environmental gradients shape microbial community structure and ecosystem processes in Antarctic lakes on King George Island

Yoon, Jiyoung., Lee, Hanbyul., Han, Yeongcheol., Ha, Sun-Yong., Lee, Min Kyung., Park, Kitae., Jung, Hyejin., Kang, Cheon Yun., Chae, Yong-Un., Cho, Jang-Cheon. and Kim, Ok-Sun.
Scientific Reports. 2025. 15(1).
doi: 10.1038/s41598-025-21587-1.

Antarctic lakes are extreme, oligotrophic habitats that contain microbial communities distinct from those of temperate freshwater systems. Our central question was whether these lakes host microbial communities distinct from those of non-Antarctic freshwater systems, and how environmental

variability drives community differences among Antarctic lakes themselves. We analyzed the microbial community across five lakes on King George Island via high-throughput sequencing of amplicon sequence variants (ASVs) and biogeochemical profiling. The microbial communities were dominated by Bacteroidota, Actinomycetota, and Pseudomonadota, but varied strongly with environmental gradients such as salinity, sulfate, methane, and organic carbon. Hybrid ASVs, which were ubiquitous in both water and sediment, comprised the majority of sequences and indicate that dispersal processes, alongside environmental filtering, jointly structure lake microbial communities. Functional predictions further revealed lake- and habitat-specific pathways for carbon, nitrogen, and sulfur cycling, linking microbial diversity to ecosystem processes. These findings highlight how Antarctic lake microbes are shaped by both local selective pressures and cross-habitat exchange, providing critical insights into the resilience and vulnerability of polar freshwater ecosystems under climate change.

keywords:
Microbial diversity; Antarctic lakes; Oligotrophic; Amplicon sequencing; Extreme environment

4-27 Microbiology

Environmental pH controls antimicrobial production by human probiotic *Streptococcus salivarius*

Nguyen, Dieu Linh., Saha, Subhasree., Thacharodi, Aswin., Singh, Bharat Bhusan., Mitra, Sonali., Do, Hackwon. and Kumaraswami, Muthiah.
Journal of Bacteriology. 2025. 207(6).
doi: 10.1128/jb.00059–25.

Streptococcus salivarius K12 (SAL) is an oral probiotic used to treat or prevent oral infections caused by human pathogens. SAL produces at least three antimicrobials to exert its antimicrobial activity, namely, salivaricin A and salivaricin B, and the newly identified salivabactin. Salivabactin production is catalyzed by a polyketide/non-ribosomal peptide synthase hybrid biosynthetic gene cluster (BGC), termed as *sar-BGC*. The *sar-BGC* expression and salivabactin production are transient during SAL growth *in vitro* and *in vivo*, which may

negatively impact SAL probiotic efficacy. To understand the molecular basis for transient *sar*–*BGC* expression, we assessed the impact of environmental pH on *sar*–*BGC* expression. We found that environmental acidification is a critical factor in promoting salivabactin antimicrobial activity and production by inducing *sar*–*BGC* expression. We further showed that acidic pH directly influences the quorum–sensing system that controls *sar*–*BGC* expression. During environmental acidification, SAL cytosol is acidified, which is sensed by a pH–sensitive histidine switch in the cytosolic transcription regulator, NrpR. The protonation of histidine during cytosolic acidification promotes high–affinity interactions between NrpR and its cognate intercellular signaling peptide, NIP, which leads to upregulation of *sar*–*BGC* expression. Collectively, our results indicate that SAL uses a sophisticated regulatory mechanism to orchestrate salivabactin production in an environment that is conducive to its antimicrobial activity.

keywords:
gene regulation; pH sensing; probiotic; antimicrobial production; antimicrobial activity

4-28

Zoology

Evolving to invade: Using geometric morphometrics to assess wing shape variation in the Antarctic non-native fly *Trichocera maculipennis*

Hernandez–Martelo, Jordan., Jabs, Mathias., Contador, Tamara., **Kim, Sanghee., Lee, Sook young.** and 5 others.
Zoologischer Anzeiger. 2025. 319: 70–77.
doi: 10.1016/j.jcz.2025.09.001.

Globalization has increased human movement, transforming ecosystems and introducing non–native species that threaten biodiversity, particularly in Antarctica. Due to its harsh climatic conditions, Antarctica has largely remained protected from biological invasions. However, rising human activity and environmental changes are facilitating the introduction of non–native species. The risks posed by species like *Trichocera maculipennis* are significant, as they can adapt and survive in new environments. This highlights the importance of understanding the adaptive factors that contribute to their success in order to prevent future invasions and protect the

continent’s unique ecosystem. The aim of this study was to quantify the wing morphological variation of *T. maculipennis* individuals associated with different Antarctic bases, analyzing this variation within a spatial and temporal context using morphometric tools. Samples were collected during Antarctic summer campaigns (2017/18 to 2019/20 and 2022/23) at the following research stations on King George Island: Artigas (Uruguay), Bellingshausen (Russia), Profesor Julio Escudero (Chile), and King Sejong (Korea). Morphometric analyses revealed changes in wing shape among study sites, with King Sejong individuals showing the most significant differences. Additionally, a temporal shift in wing size was observed, with specimens from 2017/18 and 2018/19 having larger average wings compared to those from 2019/20 and 2021/22. These results emphasize the importance of understanding the factors contributing to the success of non–native species to prevent future invasions and protect the unique ecosystem of Antarctica.

keywords:
King george island; Temporal variation; Invasive species; Adaptive factors; Wing morphology

4-29

Biology; Physiology

Exogenous abscisic acid enhances freeze–thaw stress tolerance in Antarctic moss *Sanionia uncinata* through coordinated antioxidant defense and osmoprotectant accumulation

Seo, Suyeon., Ahn, Yong–Yoon., Kim, Kitae., Lee, Jun Hyuck., Min, Kyungwon. and **Lee, Hyoungseok.**
Cryobiology. 2025. 121.
doi: 10.1016/j.cryobiol.2025.105325.

Abscisic acid (ABA) is known to improve plant freeze–thaw stress tolerance (FTST), but its role in Antarctic mosses remains largely unexplored. Accordingly, this study investigated the effects of exogenous ABA application on FTST of gametophore *Sanionia uncinata*, one of the most widespread moss species in maritime Antarctica. Samples were treated with 10 μ M ABA for 72 h under controlled culture conditions, then subjected to freezing stress at –13 and –16°C. Various physiological parameters were measured to assess ABA–induced FTST,

including ion–leakage, photosynthetic efficiency (Fv/Fm), malondialdehyde (MDA) content, compatible solutes/ osmolytes (proline and total sugars), and antioxidant enzyme activities, e.g., superoxide dismutase (SOD), catalase (CAT), and ascorbate peroxidase (APX). Gametophores treated with ABA efficiently assimilated ABA, evident by ~20–fold higher than controls. ABA application did not impede gametophore growth but slightly increased dry weight/fresh weight ratio (5 % increase). ABA significantly improved freezing tolerance, reducing freeze–induced membrane injury by ~20 % at both stress temperatures, alleviating oxidative stress with 25–34 % lower MDA accumulation, and enhancing PSII maximum quantum yield (Fv/Fm) by 6–7 % following freeze–thaw stress. Improved FTST was paralleled by enhanced activities of antioxidant enzymes, CAT and APX increasing by ~11 % and 56 %, respectively, while SOD remained unchanged. ABA treatment also promoted osmoprotectant accumulation, with proline content increasing by 33.5 % and total soluble sugars nearly doubling (99 % increase). These findings provide the first quantitative evidence that exogenous ABA markedly improves FTST in an Antarctic moss through coordinated antioxidant defense and osmoprotectant accumulation, highlighting ABA as a critical regulator of stress resilience in *S. uncinata*.

keywords:
Absciscic acid; Antioxidant enzymes; Freeze–thaw stress tolerance; *Sanionia uncinata*; Osmoprotectants

4-30

Exploiting CotA laccase from Antarctic *Bacillus* sp. PAMC28748 for efficient mediator-assisted dye decolorization and ABTS regeneration

Karmacharya, Jayram., Shrestha, Prasansah., Han, So–Ra., **Lee, Jun Hyuck.** and Oh, Tae–Jin.
Chemosphere. 2025. 372: 144137–144137.
doi: 10.1016/j.chemosphere.2025.144137.

Laccases are of particular interest in addressing environmental challenges, such as the degradation of triphenylmethane (TPM) dyes, including crystal violet (CV) and Coomassie Brilliant Blue (CBB), which are commonly used in SDS–PAGE for protein visualization. However, these dyes present significant

environmental concerns due to their resistance to degradation, which makes their removal from industrial wastewater a major challenge. To address this, the current study investigates the potential of a novel CotA laccase derived from *Bacillus* sp. PAMC28748, an Antarctic bacterial isolate, for decolorizing these stubborn dyes. The CotA gene was successfully cloned and expressed, and the enzyme demonstrated optimal activity at pH 3 and 50°C, which favors its maximum catalytic performance. The recombinant *Bacillus* sp. PAMC28748 rBCLac effectively decolorized CBB without additional mediators, whereas the degradation of CV required the use of the redox mediator ABTS. With ABTS, over 90 % decolorization was achieved at a 0.35 % concentration of CV after 240 min of incubation. Further investigation through molecular docking studies revealed that hydrogen bonding and hydrophobic interactions between the enzyme and the dye molecules are critical for effective degradation, highlighting the enzyme’s specific interaction mechanisms. In addition to its catalytic effectiveness, the study also demonstrated the practical potential of the rBCLac system by recovering and reusing both ABTS and rBCLac through ultracentrifugation and acetone precipitation. The process maintained over 75 % efficiency across three cycles, despite a slight decline in enzyme activity, thus showcasing the system’s sustainability and reusability. These findings collectively suggest that rBCLac, isolated from an extreme Antarctic environment, holds considerable promise as a candidate for the removal of industrial wastewater containing persistent dyes, with the added potential for cost–effective and sustainable water treatment through the reuse of both the enzyme and its mediator.

keywords:
Antarctica; *Bacillus* sp. PAMC28748; Recombinant CotA laccase; Crystal violet; Coomassie brilliant blue; Decolorization

4-31

Chemistry, Multidisciplinary

Exploring the Anti-Inflammatory Potential of a Steroid from Antarctic Lichen *Umbilicaria antarctica* (L.) Ach.: In Vitro, In Vivo Zebrafish Assay, and In Silico Studies

Sim, Jae Heon., Shin, Sung Woo., Heo, Eun Jin., Kim, Na Woo., **Lee, Jun Hyuck., Youn, Ui Joung.** and 2 others.
Chemistryselect. 2025. 10(20).
doi: 10.1002/slct.202406180.

Chemical analysis of the Antarctic lichen *Umbilicaria antarctica* (L.) Ach. led to the isolation of four compounds (1–4). Among these, 9,11–dehydroergosterol peroxide (3) demonstrated the most substantial anti–inflammatory effects both in vitro and in vivo using zebrafish models. Molecular docking studies were conducted to assess the binding affinities of the selected compounds with important inflammatory mediators iNOS and IL–10, and molecular dynamics (MD) simulations were performed on the most potent anti–inflammatory compound. RMSD plot analysis indicated that 3 remained stable throughout a 200 ns simulation period, particularly with iNOS. RMSF plots also suggested a stable and well–fitted conformation of 3 within the binding site of iNOS. The complex stability during the simulation is attributable to the hydrophobic interactions of 3 with TRP463, which contributed over 40% to the protein–ligand interactions. These findings suggest that 9,11–dehydroergosterol peroxide (3) could be a promising new strategy for treating inflammation.

keywords:
Antarctic lichen; Anti–inflammation; Molecular docking; Molecular dynamics; *Umbilicaria antarctica*

4-32

Environmental Sciences; Geography, Physical; Geosciences, Multidisciplinary

First report of bumblefoot in the south polar skua (*Stercorarius maccormicki*)

Kim, Youmin., Kim, Jong– U., Oh, Younggeun. and Kim, Jeong–Hoon.
Antarctic Science. 2025. 37(1): 67–68.
doi: 10.1017/s0954102024000452.

keywords:
Antarctica; Inexpressible Island; pododermatitis; south polar skua

4-33

Infectious Diseases; Veterinary Sciences

Genetic Evidence of Active Circulation and Evolution of Diverse Penguin Siadenoviruses in Antarctica Based on Partial DNA Sequences

Lee, Sook–Young., Kim, Sanghee., Kim, Ji Hee., Kim, Jong– U., Kim, Jeong–Hoon., Kim, Jihee., Oh, Younggeun. and Song, Jin–Won.
Transboundary and Emerging Diseases. 2025. 2025(1).
doi: 10.1155/tbed/5932514.

Antarctica, one of the most isolated and extreme regions on Earth, hosts diverse bird species that share breeding and feeding habitats, facilitating interspecies transmission of pathogens. In this study, we investigated penguin siadenoviruses using cloacal swab samples collected from Antarctic penguins between 2017 and 2023 to explore their genetic diversity and evolutionary relationships. The complete hexon gene was obtained from Ad & eacute;lie penguins, while partial hexon and DNA polymerase sequences were detected in Ad & eacute;lie penguin (AP), chinstrap penguin (CP), and gentoo penguin (GP). Phylogenetic and molecular analysis identified multiple siadenoviruses classified into two distinct lineages, indicating ongoing viral evolution in this region. The hexon genes exhibited considerable genetic diversity caused by recombination and mutation, and predicted hypervariable regions (HVRs)–targets of neutralizing antibodies–showed significant structural differences among penguin siadenoviruses. These findings suggest that penguin siadenoviruses are not restricted to a single host species but may circulate among various penguin populations across the Antarctic region. This implies potential cross–infection between local and surrounding penguin populations. Although the predicted structural models showed limited accuracy due to the use of distant templates, the genetic and structural differences observed provide valuable insights into the adaptive evolution of these viruses. Our findings provide an important foundation for understanding viral transmission and evolution in Antarctic avifauna. Furthermore, findings from this study may guide early detection and risk assessment of emerging viral threats in Antarctica.

4-34

Multidisciplinary Sciences

Genetic isolation and metabolic complexity of an Antarctic subglacial microbiome

Kim, Kyung Mo., Hwang, Kyuin., Lee, Hanbyul., Cho, Ahnna., Davis, Christina L., Christner, Brent C., Priscu, John C. and Kim, Ok–Sun.

Nature Communications. 2025. 16(1).
doi: 10.1038/s41467–025–62753–3.

Microbes inhabiting and evolving in aquatic ecosystems beneath polar ice sheets subsist under energy–limited conditions while in relative isolation from surface gene pools and their common ancestral populations of origin. Samples obtained from beneath West Antarctic Ice Sheet (WAIS) allowed us to examine evolutionary relationships of and identify metabolic pathways in microbial genomes recovered from the Mercer Subglacial Lake (SLM) ecosystem. We obtained 1,374 single–cell amplified genomes (SAGs) from individual bacterial and archaeal cells that were isolated from samples of SLM’s water column and sediments. These genomes reveal that a diversity of microorganisms including Patescibacteria exists in SLM. Comparative analyses show that most genomes correspond to new species and taxonomic groups, with phylogenomic and functional evidence supporting their genetic isolation from marine and surface biomes. Genomic data reveal diverse metabolisms in SLM that are capable of oxidizing organic and inorganic compounds via aerobic or anaerobic respiration. Distinct metabolic guild structures are observed for the subglacial populations, where trophic shifts from organotrophy to chemolithotrophy may depend on oxygen availability. Our SAG data suggest versatile metabolic capabilities in the characterized microbial assemblage, reveal key energy–generating strategies in the subglacial aquatic ecosystem, and provide a framework to assess microbial evolution beneath WAIS.

4-35

Genome analysis of Arctic soft rot bacterial pathogens and comparative analysis with a Korean isolate

Kim, Dockyu., Jeon, Jehyun., Woo, Sungho., Kim, Mincheol., Kim, Han–Woo. and Lee, Yung Mi.
Korean Journal of Microbiology. 2025. 61(3): 254–256.
doi: 10.7845/kjm.2025.5063.

Soft rot–causing *Pseudomonas* spp. strains (G4–2, BA90–3, and CAM17–5) isolated from Arctic rhizosphere soils and a freshwater lake sediment, along with the Korean isolate

Pectobacterium carotovorum KACC16999, were used for comparative analysis of metabolic traits and pathogenicity. Each genome consisted of a single circular chromosome and contained no plasmids: 6.1 Mb with a G + C content of 59.47% for G4–2; 7.1 Mb and 60.47% for BA90–3; 6.1 Mb and 59.93% for CAM17–5; 5.3 Mb and 51.57% for KACC 16999. Comparative analysis using RAST server revealed that five Arctic isolates (including Arctic soft rot pathogens *Pseudomonas* strains N3–W and G2–4) possess broader metabolic gene repertoires than KACC16999, particularly in amino acid and carbohydrate metabolism categories. These traits suggest their adaptation to Arctic oligotrophic environments.

keywords:
bacterial pathogen; dormant; global warming; permafrost soil; soft–rot virulence gene

4-36

Ecology; Marine & Freshwater Biology

Genome survey and microsatellite marker development in the Antarctic Eaton’s skate, *Bathyraja eatonii* (Rajiformes, Arhynchobatidae)

Kim, Jinmu., Kim, Jangyeon., Choi, Soyun., Cho, Minjoo., Choi, Eunkyung., Lee, Seung Jae., Kim, Jeong–Hoon. and Park, Hyun.
Regional Studies in Marine Science. 2025. 90.
doi: 10.1016/j.rsma.2025.104432.

Eaton’s skate (*Bathyraja eatonii*) is an endemic Antarctic cartilaginous fish species that primarily inhabits the southern coast of the Antarctic Peninsula and is also distributed across the Kerguelen Plateau near the South Shetland and South Orkney Islands. However, genomic resources for this species remain notably scarce, limiting our understanding of its genetic diversity, population structure, and evolutionary history. To address this knowledge gap, we conducted the first whole–genome survey of *B. eatonii*. Using 25–mer analysis, we estimated the genome size to be 1.84 Gb, with a heterozygosity rate of 0.26 %. De novo assembly using MaSuRCA yielded over 877,000 scaffolds, with an N50 value of 3572 bp. A total of 1383,652 microsatellite loci were identified, the majority of which were dinucleotide repeats (1163,997; 84.12 %). Among 30 randomly selected primer pairs, 15 consistently produced single, specific amplification

bands. These findings provide critical baseline data on the genomic architecture of *B. eatonii* and represent the first set of molecular markers available for future studies focused on the conservation, evolutionary biology, and population genetics of this species.

keywords:
Bathyraja eatonii; Genome survey; MaSuRCA; Microsatellite loci; Dinucleotide repeat

4-37

Biotechnology & Applied Microbiology; Environmental Sciences

Genomic and transcriptomic insights into benzoate and 4-hydroxybenzoate degradation in *Arthrobacter* sp. PAMC25564 isolated from cryoconite

Ghimire, Nisha., Kim, Byeollee., Han, So-Ra., **Lee, Jun Hyuck.** and Oh, Tae-Jin.
International Biodeterioration & Biodegradation. 2025. 203.
doi: 10.1016/j.ibiod.2025.106125.

Arthrobacter sp. has long been recognized for its metabolic versatility, particularly in the degradation of xenobiotic compounds. They have been isolated from diverse environments, including extreme environments. In this study, we conducted biotransformation, genomics and transcriptomics of *Arthrobacter* sp. PAMC25564 isolated from the cryoconite of Wurmkogel, Ötztaler Alps, Austria, one of the extreme environments to unveil its aromatic compound-degrading potential. The strain possesses several genes associated with aromatic compound catabolism including at least one complete pathway to utilize two peripheral intermediates, 4-hydroxybenzoate (4-HB) and benzoate, which are mostly determined as wastewater contaminants. *Arthrobacter* sp. PAMC25564 tolerated and degraded benzoate and 4-HB up to 25 mM. Further, RNA-seq transcriptomics was done to investigate the benzoate and 4-HB degradation pathway in PAMC25564. The results indicate global gene regulation and pathway redundancy. Furthermore, growth of the strain in these aromatic compounds upregulates multiple genes associated with amino acid metabolism and phenylacetate degradation, which are associated with stress response. These findings contribute to a better understanding of aromatic compound degradation with a special focus on wastewater

contaminants, benzoate and 4-HB degradation in *Arthrobacter* sp. PAMC25564.

keywords:
Aromatic compound degradation; 4-Hydroxybenzoate; benzoate; Genomics; Transcriptomics

4-38

Multidisciplinary Sciences

Genomic resources of Cold-adapted *Mrakia* yeasts and their potential biotechnological applications

Shin, Seung Chul., Nguyen, Dieu Linh., **Jeong, Chansu., Lee, Yung Mi., Lee, Jun Hyuck., Han, Se Jong.** and Kim, Han-Woo.
Scientific Reports. 2025. 15(1).
doi: 10.1038/s41598-025-29037-8.

Mrakia is a cold-adapted yeast genus commonly found in polar environments, including the Antarctic and Arctic regions. Several *Mrakia* genome sequences have been reported to date; however, comprehensive genomic analyses remain limited. Further, there are no reports of complete mitochondrial genome sequences for the genus *Mrakia*. Therefore, we isolated two cold-adapted yeast strains, *Mrakia gelida* PAMC 26583 and *Mrakia robertii* PAMC 26600, from Arctic lichens. Phylogenetic analysis placed both strains within the order Cystofilobasidiales. High-quality whole-genome assemblies were generated using Nanopore long-read and Illumina short-read sequencing, resulting in nearly complete nuclear and mitochondrial genomes. Analyses of gene family expansion and contraction revealed lineage-specific enrichment in functions associated with nucleosome assembly, DNA repair, metal ion binding, and membrane transport. Functional annotation identified numerous carbohydrate-active enzymes and peptidases with potential industrial applications. Both strains also exhibited ethanol production under low dissolved oxygen conditions, underscoring their utility in low-temperature fermentation. Notably, the mitochondrial genome annotation presented here represents the first reported for the order Cystofilobasidiales, providing valuable taxonomic insights into the class Tremellomycetes. These genomic resources will support future evolutionary studies and the development of biotechnological applications involving cold-active enzymes and low-temperature fermentation.

4-39

Multidisciplinary Sciences

Greenlandic water bears reveal a new morphological trait of external head sensory organs

Kihm, Ji-Hoon., Zawierucha, Krzysztof., Rho, Hyun Soo. and **Park, Tae-Yoon S.**
Scientific Reports. 2025. 15(1).
doi: 10.1038/s41598-025-06766-4.

Tardigrades are microscopic panarthropods renowned for their ability to undergo cryptobiosis. While integrative taxonomy of tardigrades has been intensively applied in the description of tardigrade species over the past two decades, many details of their external morphology remain poorly recognized and under-described. This limitation is largely due to their small size and the limited morphological features useful for classical taxonomy. In particular, compared to heterotardigrades, the external sensory structures of eutardigrades are less studied. In this study, we present a detailed morphological analysis using FE-SEM of two Greenlandic apochelan species, *Milnesium grandicupula* sp. nov. and *M. cf. longiungue*. We identified several previously unobserved anatomical structures in milnesiids, including minute sensory structures in the cephalic region. Detailed microphotographs revealed that apochelan tardigrades also possess a set of external sensory structures on the head sensory fields, similar to those observed in other major evolutionary lineages within tardigrades. This finding corroborates the hypothesis of the homology of head sensory organs between eutardigrades and heterotardigrades. Notably, these small sensory structures exhibit a distinctive pattern: a relatively large central organ surrounded by smaller pores, which may be comparable to the sensory dorsal organ (SDO) of crustaceans and the cephalic median organ (CMO) of trilobites.

keywords:
Anatomy; Cephalic sensory organ; Arctic; Meiofauna; Ancestral character

4-40

Soil Science

Humic substance turnover by bacterial decomposers in the maritime Antarctic soil

Kim, Dockyu., Kim, Mincheol., Woo, Sungho., Kim, Eungbin. and **Lee, Hyoungseok.**
Soil Research. 2025. 63(5).
doi: 10.1071/sr25001.

Context Soil fungi and bacteria play a crucial role in decomposing soil organic matter (SOM) and providing nutrients to terrestrial ecosystems. However, in polar environments, their relative contributions to decomposition remain unclear. Aims This study aimed to determine whether fungi or bacteria contributes more to humic substances (HS) decomposition (the largest constituent of SOM) in maritime Antarctic soils under controlled laboratory conditions with elevated temperature and moisture levels. Methods Soil culturing method was used to select for soil microbes that efficiently degrade HS. During culturing at 18°C for 30 days, Antarctic soils were treated with selective antimicrobials to manipulate microbial communities. After culturing, HS degradation and bacterial communities were analysed. The effects of soil culturing on plant growth were also evaluated using *Arabidopsis thaliana* as a surrogate for Antarctic plants. Key results HS decomposition and solubilisation were more pronounced in antifungal-treated soils compared to antibacterial-treated soils. Antifungal treatment reduced bacterial alpha diversity, altered bacterial composition, and increased the abundance of rhizosphere-associated Saccharibacteria. Bacterial growth resumed quickly after antibacterial treatment indicating resilience to antimicrobials. Soil culturing resulted in a higher water-soluble HS fraction, which significantly enhanced the fresh and dry weights of *A. thaliana*.Conclusions Antarctic bacteria exhibit higher degradative activity and resilience to antimicrobials compared to fungi, promoting HS decomposition and solubilisation. This indicates that bacteria have a greater impact on Antarctic soil functioning than fungi. Implications These findings highlight the critical role of bacteria in nutrient cycling and plant growth in polar ecosystems.

keywords:
Antarctic tundra; bacterial decomposers; dissolved organic matter; fungal decomposers; global warming; humic substances; plant growth promotion; solubilisation

4-41

Biochemistry & Molecular Biology; Chemistry, Applied; Polymer Science

Ice affinity purification system for recombinant proteins using a DUF3494 ice-binding protein

Hoang, Trang., Nguyen, Dieu Linh., Kim, Bomi., Choi, Woong., Cho, Sung Mi., Kim, Han-Woo., Han, Se Jong., Kim, Kitae., Lee, Jun Hyuck. and Do, Hackwon.
International Journal of Biological Macromolecules. 2025. 315.
doi: 10.1016/j.ijbiomac.2025.144378.

Protein purification is essential for the isolation of specific proteins from mixtures. Conventional affinity tags have advanced recombinant protein purification. However, their reliance on costly resins and complex procedures often limits scalability and affordability. In this study, we identified three ice-binding domains (*ColBD1*, *ColBD2*, and *ColBD3*) in *Candidatus Cryosericum* odellii SMC5 to evaluate their potential as protein purification tags. These domains exhibited hyperactive ice-binding properties, including high thermal hysteresis and ice recrystallization inhibition activities; additionally, they bound to multiple ice planes, enabling efficient attachment to ice surfaces. Through sequence and structural analyses, we engineered an enhanced variant that retained these ice-binding traits while achieving improved thermal and chemical stability: e*ColBD1*. We then used e*ColBD1* as a fusion tag to develop the Ice Affinity Purification (IAP) system and evaluated its performance with GFP as a model protein. The IAP system achieved 87 % purity after two purification rounds, recovering 29 % of the initial protein from the crude extract. Consistent performance was observed in the presence of additives such as dithiothreitol and glycerol. The IAP system provides a cost-effective, environmentally friendly alternative to traditional methods by leveraging ice as a renewable binding medium, thereby eliminating the need for expensive resins or regeneration steps.

keywords:
Ice-binding protein; DUF3494; Protein purification method

4-42 Microbiology

Identification and characterization of a novel, low-temperature-active GH8 endo-β-1,4-glucanase exhibiting broad pH stability from Antarctic *Glacieibacterium* sp. PAMC 29367

Kim, Do Young., Lee, Yung Mi. and 3 others.
Frontiers in Microbiology. 2025. 16.
doi: 10.3389/fmicb.2025.1682092.

Endo-β-1,4-glucanase plays an essential role in the breakdown of cellulosic substances that consist of D-glucose units linked by β-1,4-glycosidic bonds. In this work, the gene encoding a novel extracellular glycoside hydrolase (GH) family 8 endo-β-1,4-glucanase (GluS) from *Glacieibacterium* sp. PAMC 29367, an Antarctic lichen (*Megaspora verrucosa*)-associated bacterial species, was identified, cloned, and characterized. The GluS gene (1080-bp) was predicted to express a non-modular endo-β-1,4-glucanase (38,347 Da) that possesses a single catalytic GH8 domain, showing 65.5% amino acid sequence identity with an uncharacterized endoglucanase from *Alphaproteobacteria* bacterium (GenBank accession number: PZN92894). Recombinant endo-β-1,4-glucanase proteins (rGluS: 39.0 kDa) produced in *Escherichia coli* BL21 exhibited the highest carboxymethylcellulose (CMC)-degrading activity at pH 5.0 and 40°C, while maintaining over 80% of maximal endo-β-1,4-glucanase activity even at 25°C. Furthermore, the enzyme exhibited notable stability across a broad pH range from 4.5 to 10.0. rGluS activity was greatly stimulated by >1.3-fold in the presence of 1 mM Co²⁺, whereas it was nearly completely inhibited by 0.5% sodium dodecyl sulfate or 5 mM N-bromosuccinimide. The specific activity (31.1 U mg⁻¹) and *k_{cat}/K_m* (11.02 mg⁻¹ s⁻¹ mL) values of rGluS for CMC were marginally greater than those for barley β-1,3-1,4-glucan, with a specific activity of 28.9 U mg⁻¹ and *k_{cat}/K_m* of 8.79 mg⁻¹ s⁻¹ mL for barley β-1,3-1,4-glucan. The recombinant enzyme demonstrated no detectable biocatalytic activity for *p*-nitrophenylglucopyranoside, *p*-nitrophenylcellobioside, D-cellobiose, and D-cellotriose, while it could cleave D-cellotetraose to generate two molecules of D-cellobiose. Moreover, rGluS-mediated degradation of D-cellopentaose led mainly to D-cellobiose production along with D-glucose and D-cellotriose, while its hydrolysis of CMC yielded D-cellotriose as the dominant end product, accompanied by D-glucose, D-cellobiose and D-cellotetraose. The substrate preferences and degradation profiles of rGluS on cellulosic materials supported its classification as a true GH8 endo-acting β-1,4-glucanase without transglycosylation activity. The findings of this study suggest that rGluS represents a novel, highly active, cold-adapted GH8 endo-β-1,4-glucanase exhibiting broad pH stability, and may serve as an effective candidate for low-temperature processing in the food and textile industries.

keywords:
GH8; endo-β-1; 4-glucanase; cold-adapted enzyme; broad pH stability; Antarctic; *Glacieibacterium* sp.

4-43

Impacts of deglaciation on biodiversity and ecosystem function

Losapio, Gianalberto., Lee, Jasmine R., Fraser, Ceridwen I., Gillespie, Mark A. K., Kerr, Nicky R., Zawierucha, Krzysztof., Hamilton, Trinity L., Hotaling, Scott., Kaufmann, Rüdiger., Kim, Ok-Sun. and 5 others.
Nature Reviews Biodiversity. 2025. 1(6): 371–385.
doi: 10.1038/s44358-025-00049-6.

Glaciers and glacially influenced ecosystems host unique biodiversity spanning all kingdoms of life, but glaciers are retreating as the global climate warms, threatening specialist species, ecosystem functions and stability. We outline the impacts and consequences of glacier retreat, identifying key drivers and mechanisms of change, focusing on biodiversity and interactions among glacier, terrestrial, freshwater and marine ecosystems. We identify global glacial biodiversity patterns and local nuances, highlighting taxa that are likely to thrive or decline with the loss of glaciers. Following glacier retreat, the availability and size of ice-free areas initially increase, leading to a 'biodiversity peak'. However, as glaciers disappear, the formation of novel habitats decreases while communities become more homogeneous and competition increases, leading to local-to-regional biodiversity decline. Glacier loss influences multiple ecosystem functions that contribute to climate regulation, freshwater resources, carbon and nutrient cycling, soil development, primary productivity and food-web stability. Key challenges in glacier ecosystem science include improving our knowledge of the relationships between biodiversity and ecosystem functions and quantifying species interactions at local-to-global scales to improve mechanistic understanding. Such advances will enhance predictions of how biodiversity will change with the loss of glaciers, enabling informed and effective conservation and management.

4-44 Biodiversity Conservation; Ecology

Inference from eDNA-based field distributions vs laboratory analysis of isolated strains: physiological performance of non-marine Antarctic biota

Novis, Phil M., Monks, Adrian., Hunt, John E., Adams, Byron., Dhami, Manpreet K., Kim, Ji Hee. and 5 others.
Polar Biology. 2025. 48(1).
doi: 10.1007/s00300-025-03356-y.

Environmental DNA (eDNA) is frequently used to infer distributions of microorganisms in Antarctica. Their distributions relative to environmental variables are, in turn, sometimes used to infer their physiological range (and a relationship between the two is generally assumed for conservation purposes). We sought to determine whether ecological inferences based on distributions accurately reflect tolerances of the organisms concerned, using 249 legacy non-marine samples from a latitudinal gradient between 72 and 86 degrees S, Antarctica. A cyanobacterium, a heterotrophic bacterium, two eukaryotic algae, two fungi, and a moss were isolated into culture, and their field distributions inferred using eDNA analysis of the samples above. Tolerances of each organism with respect to environmental predictors were then inferred from the eDNA distribution and metadata using Generalised Additive Models. We then measured growth of the cultured isolates in response to a set of these predictors. Laboratory responses were then compared to inferences from the eDNA/metadata. Predictions from eDNA/metadata agreed with the results of physiological laboratory experiments for strains that were detected at high taxonomic resolution in the field samples. However, errors were never completely eliminated, and direct contradictions occurred when strains were represented at lower taxonomic resolution in the field data. We found that accurate ecological inference from eDNA studies would be best achieved via maximising both taxonomic resolution (through marker choice/read length) and ecological signal (through careful sampling design and rigorous metadata collection).

keywords:
Antarctic; Distribution; eDNA; Inference; Microbial biodiversity; Physiology

4-45

Biochemistry & Molecular Biology;
Biotechnology & Applied Microbiology

Integrating LC-MS/MS and In Silico Methods to Uncover Bioactive Compounds with Lipase Inhibitory Potential in the Antarctic Moss *Warnstorfia fontinaliopsis*

Yamaguchi, Hirotake., Yamada, Ryoichi., Lama, Kristina., **Youn, Ui Joung.**, **Lee, Jun Hyuck.** and Oh, Tae-Jin.
Applied Biochemistry and Biotechnology. 2025. 197(4): 2734–2756.
doi: 10.1007/s12010-024-05139-3.

Antarctic organisms are known for producing unique secondary metabolites, and this study specifically focuses on the less-explored metabolites of the moss *Warnstorfia fontinaliopsis*. To evaluate their potential bioactivity, we extracted secondary metabolites using four different solvents and identified significant lipase inhibitory activity in the methanol extract. Non-targeted metabolomic analysis using liquid chromatography–tandem mass spectrometry (LC-MS/MS) on this extract predicted the presence of 12 compounds, including several not previously reported in mosses. To gain insights into their enzyme inhibitory activity, the binding affinities of these candidate compounds to lipase were evaluated through in silico molecular docking. Further validation by molecular dynamics (MD) simulations revealed that hyocholic acid and pheophorbide A form stable complexes with human pancreatic lipase (HPL). Based on these results, targeted fractionation experiments were performed, yielding eight fractions. Among these, Fractions 4 and 6, which are assumed to contain those compounds, exhibited higher lipase inhibitory activity compared to the crude extract. Additionally, pharmacokinetic properties of those compounds were analyzed using SwissADME and Molinspiration calculations, suggesting their potential as drug candidates. This study establishes a promising methodology for identifying rare bioactive compounds of low abundance in underexplored natural resources by combining LC-MS/MS analysis with molecular docking. These findings also provide new insights into the chemical ecology of Antarctic mosses and their potential applications in pharmaceutical development.

keywords:
Warnstorfia fontinaliopsis; Lipase inhibitors; LC-MS/MS; Molecular docking; Molecular dynamic simulation; Pharmacokinetic properties

4-46

Biochemistry & Molecular Biology;
Biotechnology & Applied Microbiology; Genetics & Heredity

Iris bungei Maxim. *extract* promotes brown adipocyte differentiation

Yeon, Jaegoo., Suh, Sung-Suk., **Youn, Ui-Joung.** and 3 others.
Genes & Genomics. 2025. 47(6): 761–776.
doi: 10.1007/s13258-025-01645-8.

Background: *Iris bungei* Maxim., a plant native to the desert grasslands of the Inner Mongolian Plateau and traditionally used in Mongolian medicine, has been shown to influence adipocyte differentiation in white adipose tissue. However, its effects on brown adipocyte differentiation have not been previously explored. **Objective:** This study aimed to investigate the effects of *Iris bungei* Maxim. (IB) extract on brown adipocyte differentiation, focusing on lipid accumulation, gene expression, mitochondrial biogenesis, and functionality. **Methods:** Immortalized murine brown preadipocytes were treated with IB extract during differentiation. Lipid accumulation, expression of brown adipocyte-specific genes, and mitochondrial biogenesis (MitoTracker Red staining, mitochondrial DNA content, oxidative phosphorylation protein levels) were evaluated. Additionally, mitochondrial respiration and isoproterenol-induced UCP-1 expression were analyzed to assess functional effects. Bioactive compounds in the IB extract were identified using feature-based molecular networking (FBMN) with the Global Natural Products Social Molecular Networking (GNPS). **Results:** The IB extract significantly enhanced brown adipocyte differentiation, as evidenced by increased lipid accumulation and upregulation of brown adipocyte-specific genes, such as *UCP-1*, *PGC-1 α* , and PRDM16. Moreover, mitochondrial biogenesis was notably elevated, as indicated by enhanced MitoTracker Red staining, increased mitochondrial DNA content, and upregulated oxidative phosphorylation protein expression. The extract also improved mitochondrial respiration, suggesting enhanced mitochondrial functionality. Furthermore, the IB extract amplified isoproterenol-induced UCP-1 expression, indicating its potential role in thermogenesis regulation. Additionally, FBMN-GNPS analysis identified the chemical constituents in the IB extract by mass replication in the spectral matching to those in online databanks. **Conclusion:** These findings suggest that the methanol extract of IB could be a promising agent

for promoting brown adipocyte differentiation and enhancing mitochondrial activity, with potential applications in managing obesity and metabolic disorders.

keywords:
Brown adipocyte; Differentiation; *Iris bungei*; UCP-1; Lipid accumulation

4-47

Biotechnology & Applied Microbiology; Food Science & Technology

Isolation and Characterization of Low-Temperature and High-Salinity Amylase from *Halomonas* sp. KS41843

Kim, Jin A., **Kim, Min Ju.**, **Yim, Joung Han.**, **Kim, Il-Chan.**, Rhee, Jae-Sung. and **Han, Se Jong.**
Fermentation-Basel. 2025. 11(8).
doi: 10.3390/fermentation11080465.

The polar regions harbor uniquely diverse organisms adapted to low temperatures. Strains obtained from these regions are likely to produce enzymes that are industrially useful at low temperatures. In this study, a *Halomonas* sp. strain isolated from the Antarctic Sea was cultured at 15°C to obtain partially purified α -amylase. This enzyme exhibited maximum activity at 30°C and pH 5.0, retaining over 80% of its maximum activity even at 5°C. Its activity was >1.5-fold in the presence of Co²⁺, Mn²⁺, Mg²⁺, Fe²⁺, and Na⁺, indicating enhancement by most metal ions. Halophilic strain-derived enzyme maintained up to 95% of its maximum activity even at 4 M NaCl, highlighting its potential for industrial applications and possible cost savings. In this study, the low-temperature and high-salinity active amylase produced by Antarctic Halomonas sp. KS41843 was identified as a promising candidate for future biotechnology applications.

keywords:
Halomonas; amylase; Antarctic bacterium; cold-active; halotolerant

4-48

Biotechnology & Applied Microbiology

Kraft lignin decomposition by lignin-derived aromatic compound degrader *Rhodococcus* sp. DK17

Kim, Dockyu., **Kim, Mincheol.**, **Kim, Han-Woo.**, Kim, Eungbin. and **Lee, Hyoungseok.**
World Journal of Microbiology & Biotechnology. 2025. 41(4).
doi: 10.1007/s11274-025-04350-6.

Rhodococcus sp. DK17 has been previously isolated from oil-contaminated soil and studied for its ability to degrade various monocyclic alkylbenzenes. This study investigated the decomposition of kraft lignin (genes, enzymes, and metabolic pathways) by DK17, using whole-genome sequencing data, as a potential biocatalyst for biotechnological lignin valorization. DK17 used kraft lignin and its main degradative metabolites, such as vanillin and vanillic acid, as growth substrates. High-performance liquid chromatography revealed that DK17 converted dehydrodivanillin (a representative lignin model compound). Quantitative polymerase chain reaction of mRNAs from DK17 cells induced in the presence of lignin showed that the putative genes coding for two copies of dye-decolorizing peroxidases (*dypB1* and *dypB2*) were upregulated 1.6- and 2.4-fold after 5 and 24 h of induction, respectively, compared with glucose-induced cells. Vanillic acid induced *dypB1* and *dypB2* at lower levels than lignin by 1.4- and 1.6-fold after 5 and 24 h of induction, respectively. Computational homology analysis using the DypB1 and DypB2 protein sequences also predicted their initial roles in lignin decomposition. The duplicated *dyp* genes are believed to allow DK17 to achieve prolonged and continuous initial lignin decomposition, cleaving C-C and C-O-C linkages in the main lignin structure, the arylglycerol- β -aryl ether. Based on the above data, DK17 appears to initiate oxidative lignin decomposition using DyPs, producing smaller metabolites, such as vanillin and vanillic acid, which could be accumulated as value-added bioproducts (in metabolically engineered mutant strains) or further degraded for cell growth (in wild-type strains) via an ortho-ring cleavage pathway.

keywords:
Bacterial peroxidase; Biocatalyst; Biodegradation; Kraft lignin; *Rhodococcus*

4-49

Microbiology

Longitudinal gut microbiota dynamics in Antarctic research mission crews

Lee, Min-Jung., Lee, Seung-Hwan., Min, Huitae., Nam, Tae-Wook., **Hong, Soon Gyu.** and 5 others.
Frontiers in Microbiology. 2025. 16.
doi: 10.3389/fmicb.2025.1593617.

Introduction A prolonged stay at Antarctic research stations poses unique challenges due to extreme environmental conditions, restricted diets, and cold temperatures, all of which can influence the gut microbiota, an important factor in host health. However, our understanding of how the Antarctic environment affects the gut microbiota remains limited due to small cohort sizes and short study durations. **Methods** We analyzed 467 fecal samples collected longitudinally from 48 participants who stayed at Antarctic stations for up to 16 months. **Results** Before departing to the Antarctic bases, male participants exhibited three distinct types of gut microbiota, which were differentially altered during and after the stay, depending on the pre-existing microbiota type. Prevotella-dominant microbiota was more susceptible to environmental changes, including the diet, compared with Bacteroides-dominant microbiota. Although the dominant genera in the gut microbiota were stable across all microbiota types, minor genera with high variability could mediate changes in the microbiota. Sharing diets and having frequent contact resulted in cohabitation effects among genetically unrelated participants in the extremely isolated Antarctic environment. Although taxonomic composition shifted in response to the Antarctic environment, predicted functions of the gut microbiota remained relatively stable. **Discussion** This study reveals that long-term residence in Antarctic research stations alters the gut microbiota in ways that depends on the intrinsic microbiota prior to the mission. These findings enhance our understanding of human gut microbiota adaptation under extreme and isolated environmental conditions.

keywords:
gut microbiota; Antarctica; extreme environment; variability; cohabitation

4-50

Multidisciplinary Sciences

Metabarcoding analysis reveals hidden eukaryotic plankton biodiversity in the Ross Sea, Antarctica

Choi, Soyun., Choi, Eunkyung., Cho, Minjoo., Lee, Seung Jae., Kim, Inseo., Shin, Doyoon., Kim, Jangyeon., **La, Hyoung Sul.**, Rhee, Jae-Sung., **Kim, Jeong-Hoon.** and Park, Hyun.
Peerj. 2025. 13.
doi: 10.7717/peerj.20118.

Background: Environmental DNA (eDNA) analysis is a highly sensitive, non-destructive method that enables the detection of various species through DNA shed into environmental samples without requiring direct organism collection. This study sought to investigate the biodiversity and community structure of eukaryotic plankton, including phytoplankton and zooplankton, in the Ross Sea marine protected area (RSR MPA) using eDNA metabarcoding analysis. By examining their spatial and vertical distributions, the study underscores the importance of continuous monitoring for the conservation of the RSR MPA. **Methods:** We collected 48 seawater samples from 16 sites in the Ross Sea region for eDNA metabarcoding analysis, targeting the 18S rRNA gene region of eukaryotic plankton in Antarctica. Bioinformatic processing and taxonomic classification were conducted to assess the diversity and community composition of phytoplankton and zooplankton. **Results:** Phytoplankton communities were primarily composed of six phyla with their distribution patterns and the grouping of samples with similar community structures was found to be shaped by the ocean currents of the RSR MPA and various environmental factors, such as salinity and dissolved oxygen levels. Zooplankton communities consisted of 18 major taxonomic groups, exhibiting distinct horizontal and vertical distribution patterns with differences in taxonomic community structure and species diversity across depth groups. Notably, previously undetected Antarctic species were identified in the Ross Sea region, demonstrating the effectiveness of eDNA in revealing hidden biodiversity. **Conclusions:** Analyzing eukaryotic plankton communities in the vast and extreme Antarctic environment based on eDNA has proven to be highly efficient, enabling the detection of a greater number of species, including those that were difficult to identify in previous studies. It was observed that in the Ross Sea Marine Protected Area, various species form distinct community structures

such as phytoplankton and zooplankton, each inhabiting the area according to different environmental variables and habitat preferences. As a designated marine protected area, the Ross Sea’s unique ecosystem requires continuous monitoring and conservation efforts to address environmental changes. The genetic data obtained in this study contributes to expanding the database of Antarctic-specific species, facilitating more accurate and efficient analyses of Antarctic ecosystems in the future.

keywords:
Ross Sea; Marine protected area; Environmental DNA; Metabarcoding; Eukaryotic diversity; Phytoplankton; Zooplankton

4-51

Multidisciplinary Sciences

Methane trapping in permafrost soils: a biogeochemical dataset across Alaskan boreal-Arctic gradient

Kim, Jinhyun., Kim, Yongwon., **Nam, Sungjin.**, **Jung, Ji Young.**, Kim, You Jin., Hwang, Jeong Ho. and **Kim, Mincheol.**
Scientific Data. 2025. 12(1).
doi: 10.1038/s41597-025-04463-5.

Permafrost soils store vast amounts of organic carbon, and their thawing due to climate warming accelerates the release of carbon as methane and carbon dioxide, exacerbating global climate change. Understanding the distribution of greenhouse gases trapped in these soils and predicting their behavior upon thawing is essential for accurately modeling climate feedbacks. This study presents an integrated biogeochemical and microbial dataset from ~ 1.8 m deep soil cores collected across a 970 km latitudinal gradient in Alaskan permafrost regions, spanning boreal forest and Arctic tundra biomes. This dataset includes vertical profiles of trapped greenhouse gases, their stable isotope signatures, soil physicochemical properties, and the composition and abundance of key methanogenic and methanotrophic genes. These data provide critical insights into methane cycling within permafrost soils in high-latitude ecosystems and contribute to refining the parameterization of biogeochemical processes in climate models, especially in the context of accelerating permafrost thaw.

4-52

Environmental Sciences; Public, Environmental & Occupational Health

Millennial-scale depth-resolved ancient microbial diversity and pathogenic potential in Styx Glacier, Antarctica

Kim, Minkyung., **Lee, Hanbyul.**, **Lee, Subin.**, **Han, Yeongcheol.** and **Kim, Ok-Sun.**
Environmental Research. 2025. 285.
doi: 10.1016/j.envres.2025.122421.

The cryosphere offers crucial insights into historical ecosystems and biomes on our planet, preserving ancient microorganisms and other biological materials. The recent discovery of pathogens released from permafrost and Arctic regions has emphasized potential threats to human health. However, the ancient microbial diversity in Antarctic glaciers remains largely unexplored. To address this gap, we investigated the microbial diversity and the presence of potential pathogens in the Styx ice core (Northern Victoria Land, Antarctica) with millennial-scale dated between 525 and 1978 CE. A total of 656 isolates, representing 27 species, were obtained by incubation on four different media at 10°C and 25°C. Among the cultured isolates, the Alphaproteobacteria was the predominant class, with *Sphingomonas echinoides* (70 % at 10°C) and *Bradyrhizobium elkanii* (76.2 % at 25°C) being the most prevalent species across all depths. Genomic analysis of four isolates (*Roseomonas mucosa*, *Gordonia hongkongensis*, *Paenibacillus glucanolyticus*, and *Dermacoccus nishinomiyaensis*) among nine species suspected to be potential pathogens was performed to identify the presence of antibiotic resistance and virulence genes. Amino acid sequences of HbhA, a mycobacterial surface antigen, in *G. hongkongensis* strains exhibit AKKA repeat motifs, similar to those found in pathogenic *Mycobacterium tuberculosis* and *Nocardia cyriacigeorgica*. Furthermore, the hemolysin produced by *R. mucosa* and *P. glucanolyticus* showed no activity at 25°C but exhibited activity at 37°C. This study demonstrated that glacial ice contains core microbiomes and also highlighted the presence of potential opportunistic pathogens, resonating between ancient microbiology and contemporary environmental health concerns.

keywords:
Glacial bacteria; Culture-dependent bacterial community; Pseudomonadota; Pathogen; Genomic analysis; Virulence factor

4-53

Marine & Freshwater Biology

Morphology and molecular characterization of a new *Chloroidium* (Trebouxiophyceae, Chlorophyta) species isolated from lichen in Antarctica

Chae, Hyunsik., Lee, Yung Mi., Lee, Hyodong., So, Jae Eun., So, Jeongha., Choi, Han-Gu., Kim, Sanghee. and Kim, Ji Hee.
Phycological Research. 2025. 73(2): 125–133.
doi: 10.1111/pre.12584.

Antarctica’s harsh environment supports a unique diversity of microalgae that inhabit freshwater, soil and snow, and engage in symbiotic associations with lichens. Among these, the photosynthetic eukaryotic algae in lichens primarily exhibit *Chlorella*-like morphology, which complicates their identification as a result of the simplicity of their form. In the present study, we aimed to identify a *Chlorella*-like strain isolated from the lichen *Psoroma antarcticum* in Antarctica based on its morphological and molecular characteristics. The strain PAMC 29142 showed ellipsoidal to almost spherical cells with parietal chloroplasts and reproduced through equally sized autospores, closely resembling other members of the genus *Chloroidium*. The phylogenetic analyses using nuclear small subunit and internal transcribed spacer rDNA sequences data confirmed that PAMC 29142 represents a distinct lineage within the genus. Internal transcribed spacer 2 secondary structures and the compensatory base changes approach were used to compare this strain with other *Chloroidium* species. Based on comprehensive morphological and molecular data, we propose the designation of PAMC 29142 as a new species, *Chloroidium psoromicola* sp. nov.

keywords:
CBC approach; morphological characteristics; photobiont; SSU and ITS rDNA

4-54

Biology

N⁵-((perfluorophenyl)amino)glutamine regulates BACE1, tau phosphorylation,

synaptic function, and neuroinflammation in Alzheimer’s disease models

Kim, Jun-Sik., Cho, Yongeun., Lee, Jeongmi., Cho, Heewon., Han, Sukmin., Lee, Yeongyeong., Jeon, Yeji., Kim, Tai Kyoung., Hong, Ju-Mi., Im, Jeonghyeong., Chae, Minshik., Lee, Yujeong., Kim, Hyunwook., Park, Sang Yoon., Kim, Sung Hyun., Yim, Joung Han. and Jo, Dong-Gyu.
Bioscience Trends. 2025. 19(1): 102–115.
doi: 10.5582/bst.2024.01360.

Alzheimer’s disease (AD) is the most common type of dementia. Its incidence is rising rapidly as the global population ages, leading to a significant social and economic burden. AD involves complex pathologies, including amyloid plaque accumulation, synaptic dysfunction, and neuroinflammation. This study explores the therapeutic potential of *N*⁵ -((perfluorophenyl)amino)glutamine (RA-PF), a derivative of γ -glutamyl-N’-(2-hydroxyphenyl)hydrazide (Ramalin), a compound with antioxidant and anti-inflammatory properties. Administration of RA-PF to 5xFAD mice decreases BACE1, reduces A β plaque deposition, inhibits microglial activation, restores synaptic transmission, and improves mitochondrial motility, leading to the recovery of cognitive function. Additionally, RA-PF treatment in 3xTg-AD mice alleviates anxiety-like behaviors, tau phosphorylation via inactivating GSK-3 β , and BACE1 expression. Further transcriptomic analysis reveals RA-PF treatment in AD mice models recovers phagosome, inflammation, NOD-like receptor, presynaptic membrane, and postsynaptic membrane related signaling pathways. These findings suggest that RA-PF effectively targets multiple aspects of AD pathology, offering a novel multi-target approach for AD treatment.

keywords:
Alzheimer’s disease (AD); ramalin; RA-PF; BACE1; tau; synaptic function

4-55

Chemistry, Multidisciplinary

Non-targeted metabolite profiling reveals biochemical diversity of three East Asian mosses

Zahra, Fatima Tuz., Min, Kyungwon., Lee, Jungeun., Jung, Maeng-Joon., Lee, Hyoungseok. and Kim, Sunghwan.
Bulletin of the Korean Chemical Society. 2025. 46(6): 641–653.
doi: 10.1002/bkcs.70032.

Mosses are known for their rich diversity in bioactive compounds and their essential role in maintaining ecosystems. While genetic and metabolomics studies have been conducted on some model species, research on comprehensive metabolomics of common mosses in East Asia remains limited. In this study, we conducted an untargeted analysis of three East Asian moss species, *Niphotrichum japonicum*, *Calohypnum plumiforme*, and *Polytrichum formosum*, by ultrasonic-assisted extraction and liquid chromatography coupled with high-resolution mass spectrometry. This approach facilitated the detailed profiling and compound classification through reference databases. Tandem mass spectrometry with positive mode tentatively identified 188, 183, and 186 metabolites, respectively, with lipids and terpenoids as the predominant class. Among these, 25 potential biomarkers were identified to differentiate between species. Multivariate analysis, including principal component analysis, revealed distinct metabolic profiles for each species, representing taxonomical differences, confirming data reproducibility, and clear species differentiation. Enrichment analysis further highlighted the upregulation of unsaturated fatty acid biosynthesis across all moss species. This is the first report utilizing an untargeted metabolomics approach with chemometrics to differentiate moss species cultivated in the same location, offering a new foundation for studying the metabolic responses of East Asian mosses.

keywords:
bryophytes; metabolite profiling; multivariate data analysis; non-targeted analysis; UPLC-Q-cIM-TOF-MS

4-56

Genetics & Heredity; Microbiology

Plant species and soil moisture shape rhizosphere microbiota in an unusually productive tundra ecosystem of North Greenland

Myeong, Nu Ri., Ryu, Youngil., Park, Tae-Yoon S., Jung, Ji Young., Jeong, Sujeong., Ju, Hyeontae., So, Yohan., Kim, Jinhyun. and Kim, Mincheol.
Environmental Microbiome. 2025. 20(1).
doi: 10.1186/s40793-025-00781-8.

Background: Arctic warming is driving uneven greening across high-latitude regions, leading to the development of unusually productive tundra ecosystems that remain poorly understood. Here, we investigated the soil physicochemical properties and multi-kingdom microbial communities (bacteria, fungi, and micro-eukaryotes) in the rhizosphere of dominant plant species in a highly productive tundra ecosystem in the central part of North Greenland (above 82°N). **Results:** A strong correlation between the normalized difference vegetation index (NDVI) and soil moisture content underscores the critical role of moisture in determining vegetation patterns. Plant species was a key determinant of microbial community structure across all microbial groups, but the strength and nature of these associations varied. Fungal communities were most affected by plant species identity, with distinct associations between mycorrhizal taxa and specific plant species observed in wetter sites. In contrast, bacterial communities were more strongly linked to vegetation-driven changes in soil geochemistry, while micro-eukaryotic communities exhibited comparatively weaker responses to both plant species and soil properties. Additionally, a positive association between nematodes and mushroom-forming fungi (mainly *Agaricomycetes*) suggests the presence of a functionally interconnected soil food web, and parasitic protists of the Apicomplexan order *Eugregarinorida* were widespread across most sites, though their ecological roles remain unclear. **Conclusions:** Taken together, our findings suggest a possible role of soil water availability in shaping plant species-specific rhizosphere microbial communities in this highly productive High Arctic tundra ecosystem. Furthermore, the multi-kingdom community data provide a valuable baseline for future research on the ecological functioning and climate sensitivity of increasingly productive Arctic ecosystems.

keywords:
Rhizosphere microbiota; Water availability; Sirius passet; North greenland; Arctic tundra

4-57

Environmental Sciences; Toxicology

Potential risks of bacterial plant pathogens from thawing permafrost in the Alaskan tundra

Kim, Dockyu., Kim, Mincheol., Woo, Sungho., Nam, Sungjin., Myeong, Nu Ri., Kim, Eungbin. and Lee, Yung Mi.

Ecotoxicology and Environmental Safety. 2025. 289.
doi: 10.1016/j.ecoenv.2024.117531.

Global warming-induced permafrost thawing raises concerns about the release of dormant microbes, including potentially harmful plant pathogens. However, the potential pathogenic risks associated with the thawing of permafrost remain poorly understood. Here, we conducted a 90-day soil incubation experiment at 4°C to mimic extended permafrost thawing in Alaskan tundra soils stratified into active (A), transitional (T), and permanently frozen (P) layers. Following incubation, we examined the changes in bacterial abundance and community composition and tested the reactivation and pathogenicity of dormant plant pathogenic bacteria. Bacterial abundance, measured by colony-forming units and 16S rRNA gene copies, distinctly increased in the T and P layers after thawing. These layers also exhibited substantial shifts in bacterial community structure, with Fecycling taxa becoming more abundant and permafrost-dominant taxa decreasing in abundance. Notably, we isolated 52 strains with proteolytic activity, and our pathogenicity tests confirmed that *Pseudomonas* spp. isolates caused potato soft rot symptoms. Some *Pseudomonas* pathogens were undetectable in the amplicon sequencing data before thawing and emerged only in the thawed T and P layers. Our findings illustrate that permafrost acts as a reservoir of potential plant pathogens, and their resurgence upon thawing poses a potential risk to Arctic ecosystems.

keywords:
Bacterial communities; Global warming; Outbreak; Permafrost thawing; Potential plant pathogen

4-58

Cell Biology; Zoology

RA-PR058, a novel ramalin derivative, reduces BACE1 expression and phosphorylation of tau in Alzheimer’s disease mouse models

Cho, Yongeun., Lee, Jeongmi., Kim, Jun-Sik., Jeon, Yeji., Han, Sukmin., Cho, Heewon., Lee, Yeongyeong., Kim, Tai Kyoung., Hong, Ju-Mi., Lee, Yujeong., Byun, Yujung., Chae, Minshik., Park, Sunyoung., Palomera, Leon F., Park, Sang Yoon., Kim, Hyunwook., Kim, Soyeong., Kang, Seongeun., Jee, Jun-Goo., An, Hongchan., Yim, Jong Han. and 2 others.

Animal Cells and Systems. 2025. 29(1): 122–134.
doi: 10.1080/19768354.2025.2459649.

Alzheimer’s disease (AD) is a multifactorial neurodegenerative disorder characterized by cognitive decline, anxiety-like behavior, β -amyloid (A β) accumulation, and tau hyperphosphorylation. BACE1, the enzyme critical for A β production, has been a major therapeutic target; however, direct BACE1 inhibition has been associated with adverse side effects. This study investigates the therapeutic potential of RA-PR058, a novel ramalin derivative, as a multi-targeted modulator of AD-related pathologies. The effects of RA-PR058 were evaluated *in vitro* and *in vivo*. In vitro studies used SH-SY5Y cells under oxidative stress conditions to assess BACE1 expression, while in vivo effects were studied in 3xTg-AD mice following one month of oral RA-PR058 treatment. Behavioral assessments, biochemical analyses, transcriptomic profiling, and pharmacokinetic evaluations were performed to determine the efficacy of RA-PR058. RA-PR058 significantly reduced oxidative stress-induced BACE1 expression in vitro and decreased cortical BACE1 expression in 3xTg-AD mice. In vivo treatment alleviated anxiety-like behavior and reduced tau phosphorylation at disease-relevant sites (Ser202/Thr205, Thr231, and Ser396). Transcriptomic analysis revealed RA-PR058-mediated gene expression changes related to central nervous system development, response to hypoxia, and neuroactive ligand-receptor interactions, suggesting broader regulatory effects on AD-related pathways. Pharmacokinetic analysis demonstrated that RA-PR058 exhibits high metabolic stability, minimal cytochrome P450 interactions, and moderate blood-brain barrier penetration. RA-PR058 demonstrates potential as a multi-target AD therapeutic by reducing BACE1 expression, tau hyperphosphorylation, and anxiety-like behavior, coupled with favorable pharmacokinetics. Additional

studies are needed to assess cognitive effects and clarify molecular mechanisms, but RA-PR058 may represent a promising advancement in addressing AD’s complex pathology.

keywords:
Alzheimer’s disease; BACE1; Tau; RA-PR058

4-59

Microbiology

Refining the genome of alkylbenzene-degrading *Rhodococcus* sp. DK17 and comparative analysis with genomes of its deletion mutants

Jeon, Jehyun., Kim, Dockyu., Kim, Eungbin. and Lee, Yung Mi.

Microbiology resource announcements. 2025. 14(4):
e0113424–e0113424.
doi: 10.1128/mra.01134–24.

Rhodococcus sp. strain DK17 degrades various alkylbenzenes, including *o*-xylene, making it a potential biocatalyst for the production of fine chemicals. DK17 carries the degradative genes on linear mega-plasmids. Here, we present the refined DK17 genome and analyze the genetic variations in UV-induced mutants DK176 and DK180.

keywords:
alkylbenzene degradation; *Rhodococcus*; UV-induced mutant; genome

4-60

Biology; Multidisciplinary Sciences

Regulation of anti-CRISPR operons by structurally distinct families of Aca proteins

Lee, So Yeon., Birkholz, Nils., Lee, Jun Hyuck. and 2 others.

Communications Biology. 2025. 8(1).
doi: 10.1038/s42003-025-09101-9.

CRISPR-Cas systems provide bacteria with adaptive immunity against bacteriophages and mobile genetic elements, driving

an evolutionary arms race in which phages deploy anti-CRISPR (Acr) proteins. Acr proteins are often co-encoded in operons with anti-CRISPR-associated (Aca) proteins, which coordinate the regulation of *acr* gene expression. Here, we reveal the molecular basis of DNA binding that mediates transcriptional repression by two distinct Aca family members: Aca7 and Aca11. Crystal structures of Aca7 and Aca11 highlight conserved helix–turn–helix (HTH) motifs within α –helix bundles, providing a universal DNA-binding platform. Aca7 forms a symmetrical dimer to recognize a 19-bp inverted repeat (IR) within the *acrI*F11–*aca*7 operon. Strikingly, Aca11 binds 22-bp IRs in two distinct promoters, suggesting that Aca proteins can control multiple target operons. Mutagenesis and electrophoretic mobility shift assays (EMSAs) confirm that dimerization and sequence-specific IR recognition are essential for DNA binding. Despite mechanistic similarities, these and other Aca proteins exhibit notable differences. Structural comparisons across Aca families reveal that while monomer structures are generally similar with conserved HTH motifs, the structures of their dimeric functional units vary significantly. These structural differences might be essential for Aca proteins to bind to various promoters and regulate the expression of different Acr proteins.

4-61

Review of Circadian Activity and Sleep Behavior in Fish and a Pilot Study

Park, Ha Young., Lee, Won Young. and 6 others.
Korean Journal of Fisheries and Aquatic Sciences. 2025. 58(6),
629–642
doi: doi.org/10.5657/KFAS.2025.0629

Animals, including fish, regulate their activity and sleep patterns via an endogenous circadian clock. Sleep is a universal phenomenon across taxa, including humans, and it serves multiple functions such as neural recovery, metabolic regulation, and immune maintenance. However, sleep in fish is difficult to define solely based on behavior; therefore, physiological and genetic indicators have commonly been used in parallel to characterize sleep-like states. These investigations were conducted primarily in a laboratory setting using video-based tracking systems. In this study, methods for assessing fish activity and sleep were reviewed, and these approaches

were applied to black and red seabream to evaluate their circadian activity patterns. Both the species exhibited stable daily activity rhythms under controlled laboratory conditions. These findings provide baseline information that can contribute to understanding the behavioral and physiological responses of aquaculture species to rising seawater temperatures associated with climate change, and to the development of appropriate management strategies.

keywords:
Circadian rhythm; Sleep behavior; Fish sleep; Activity rhythm; Locomotor analysis

4-62 Multidisciplinary Sciences

***Rhodococcus aromaticivorans* sp. nov., an o-xylene degrading bacterium, and evidence supporting reclassification of *Rhodococcus jostii* RHA1**

Muhammad, Neak., Jeon, Jehyun., Kim, Eunbin., Kim, Dockyu. and Lee, Yung Mi.
Plas One. 2025. 20(12).
doi: 10.1371/journal.pone.0337194.

A Gram-positive, aerobic, non-motile bacterium with a rod-coccus shape, designated DK17^T, was isolated from a crude oil-contaminated soil and identified as a member of the genus *Rhodococcus* based on 16S rRNA gene analysis, showing highest similarity (99.93%) to *Rhodococcus jostii* DSM 44719^T. However, average nucleotide identity (ANI) and digital DNA-DNA hybridization (dDDH) values between strain DK17T and type strains within the genus *Rhodococcus* were below the species delineation thresholds of 95% and 70%, respectively. In contrast, DK17^T exhibited ANI and dDDH values over 99% and 92%, respectively, with *R. jostii* RHA1. Comparative genomic analysis revealed that DK17T and RHA1 shared 93.5% of genes, while RHA1 and *R. jostii* NBRC 16295^T shared only 78.6%, indicating a closer relationship between DK17^T and RHA1. Both strains possess large genomes (~9.5-9.7 Mb) comprising a linear chromosome and multiple plasmids, and encode multiple dioxygenases and secondary metabolite biosynthetic gene clusters. *In vitro* assays confirmed o-xylene degradation by both DK17^T and *R. jostii* RHA1, consistent with the presence of the *akb* gene cluster. Both strains shared

C16:0 as a major fatty acid and menaquinone-8 (H2) as the dominant quinone. Based on genomic, phenotypic, and chemotaxonomic data, DK17^T (=KCCM 90599^T=InaCC B1662^T) is proposed as a novel species, *Rhodococcus aromaticivorans* sp. nov., and *R. jostii* RHA1 is reclassified as a member of the same species.

4-63 Biochemistry & Molecular Biology; Chemistry, Applied; Polymer Science

Roles of CO₂ in carbon-negative syngas production from pyrolysis of cellulosic biomass (oat hull)

Kim, Youkwan., Lee, Joohyung., Lee, Taewoo., Kim, Han-Woo. and Kwon, Eilhann E.
International Journal of Biological Macromolecules. 2025. 331.
doi: 10.1016/j.ijbiomac.2025.148455.

The biological conversion of biomass into chemicals and biofuels is environmentally beneficial. Nevertheless, it is critical to minimize the inevitable carbon loss by microbial metabolisms such as respiration and cell reproduction. Pyrolysis has gained considerable attention because it enables to utilize all carbons in biomass as the form of syngas, biocrude, and biochar. In this study, oat hull (OH), one of the by-products generated during cereal processing, was selected as a model biomass. To impart the sustainability of pyrolysis process, carbon dioxide (CO₂) was used as a partial oxidant. CO₂ participated in homogeneous gas-phase reactions (HGRs) with volatile matters (VMs) derived from OH pyrolysis, resulting in the enhanced formation of carbon monoxide (CO). However, the HGRs induced by CO₂ are evident only above 550°C. To expedite the reaction kinetics of CO₂, pyrolysis experiment was carried out in a reactor system equipped with external heating at 700°C and loaded with Ni/Al₂O₃ catalysts (0.5, 2.0, and 5.0 wt% Ni). The use of Ni catalyst during OH pyrolysis enhanced the thermal cracking of the VMs into lighter molecular volatiles, accelerating the HGRs with CO₂ under improved mass transfer. The production of CO-rich syngas increased proportionally to the Ni loading on the catalysts. Therefore, this study highlights mechanistic insights into the roles of CO₂ in facilitating CO-rich syngas production, with enhancing carbon utilization efficiency during the OH pyrolysis

keywords:
Pyrolysis; Cellulosic biomass; Carbon-negative syngas

4-64

Secondary Metabolites Isolated from the Methanol Extract of *Pseudocyphellaria freycinetii* and Their Cytotoxicity

Koo, Man Hyung., Kim, Hye Ji., Kim, Seong Hye. and Youn, Ui Joung.
Korean Journal of Pharmacognosy. 2025. 56(2): 80-85.
doi: 10.22889/kjp.2025.56.2.80

Phytochemical study of the lichen, *Pseudocyphellaria freycinetii* (Lobariaceae) led to the isolation of two hopane-type triterpenoids (1 and 2), along with two phenolic compounds (3 and 4). The structures of the compounds were identified by 1D and 2D NMR, and MS experiments, as well as by comparison of their data with published values. Compounds 2-4 were isolated for the first time in this species. All the compounds were evaluated for their cytotoxicity. Among the isolates, compound 1 showed considerable inhibitory activity against the Hela cell growth.

keywords:
Cytotoxicity; Hopane-type triterpenoid; *Pseudocyphellaria freycinetii*

4-65 Marine & Freshwater Biology

Spatial environmental heterogeneity of ocean currents affects pelagic ciliate community structure, assembly, and co-occurrence network complexity in the Scotia Sea, Antarctic

Shi, Tianjing., Cao, Furong., Shu, Wangxinze., Jiang, Yurou., Yang, Eun Jin. and 3 others.
Marine Life Science & Technology. 2025. 7(4): 757-778.
doi: 10.1007/s42995-025-00308-7.

The complex current systems of the Southern Ocean play a critical role in shaping the heterogeneity and distinctiveness of Antarctic habitats. Nonetheless, how Antarctic water masses influence ciliates, one of the most common groups of protozoa in polar regions, remains largely unknown. The

present study investigated how the ciliate communities are affected by complex Southern Ocean currents by analyzing the diversity distributions, community assembly mechanisms, and co-occurrence networks of ciliates across three distinct water masses in the Scotia Sea. The findings reveal that the hydrography of the Scotia Sea significantly affects the spatial patterns of planktonic ciliates, primarily through the combination of temperature, salinity, and depth. In contract to surface waters (Antarctic Surface Water and Antarctic Circumpolar Current), ciliates inhabiting deep waters (Circumpolar Deep Water) exhibit stronger and more direct correlations with the environment parameters, alongside greater network stability. Community assembly in surface and deep-water masses is governed by stochastic and deterministic processes, respectively. Compared to other Antarctic regions documented in previous studies, the Scotia Sea demonstrated the lowest alpha diversity indices for ciliates while harboring the highest number of endemic species. A detailed re-evaluation of Antarctic ciliate community structure in the Antarctic from prior research offers valuable insights into how dynamic ocean currents shape the ecological dynamics of ciliate communities, thus providing a broader understanding of the environmental changes impacting polar marine ecosystems.

keywords:
Ciliated protists; Co-occurrence network; Microbial community assembly; Polar water masses; Southern Ocean

4-66

Study on the Establishment of Korean Names and Naming Principles for Antarctic Fish Species

Kim, Jin-Hyoung., Kim, Eunjung., Kim, Il-Chan., Kim, Jeong-Hoon. and 3 others.
Korean Journal of Ichthyology. 2025. 37(3): 168-181.
doi: 10.35399/ISK.37.3.2.

Fish inhabiting the Southern Ocean exhibit unique physiological and morphological adaptations to extreme environments and play a vital role in the ecosystem. However, in South Korea, the standardized Korean nomenclature for Antarctic fish species has not been systematically established, posing challenges for academic research and educational resource development.

This study aims to establish Korean names for 147 species of fish inhabiting the Southern Ocean, including those with existing Korean names, and to present the principles and methodology applied in the naming process. Based on a review of existing literature, we examined the naming conventions employed by the National Institute of Fisheries Science (NIFS) and the Korea Polar Research Institute (KOPRI). We established naming principles that consider ecological and morphological characteristics. Furthermore, we ensured consistency by aligning the newly proposed names with internationally recognized scientific and English names. The results indicate that names reflecting habitat and morphological or ecological traits are effective in enhancing public understanding, and that maintaining continuity with existing Korean names is essential. This study is expected to contribute to future research on Antarctic fish and the development of educational resources.

keywords:
Antarctic fishes; Southern Ocean; fish taxonomy; Korean nomenclature; scientific name

4-67

Biochemistry & Molecular Biology; Chemistry, Medicinal; Food Science & Technology

Superoxide Dismutase 3 Deficiency Disrupts the Regulation of Oxidative Stress Caused by Polystyrene Nanoplastics

Sim, Yugyeong., Kim, Jin-Hyounge. and 3 others.
Antioxidants. 2025. 14(11).
doi: 10.3390/antiox14111378.

Nanoplastics have been recognized as emerging pollutants posing potential risks to ecosystems and human health. They are now detected ubiquitously in the environment and even human tissues, where their small size allows for tissue accumulation and cellular penetration. Growing evidence links nanoplastics to oxidative stress, yet the specific contribution of extracellular accumulation to toxicity remains poorly understood. To address this, we used zebrafish, a transparent vertebrate model suitable for toxicological studies, to explore the role of extracellular antioxidant defenses in polystyrene nanoplastic (PSNP)-induced oxidative stress. In particular, we focused on superoxide dismutase 3 (SOD3), which is an enzyme that regulates extracellular reactive oxygen species by catalyzing

the detoxification of superoxide radicals. Zebrafish Sod3a is a homolog of human SOD3, preserving conserved metal-binding sites critical for enzymatic function. We established sod3a mutant zebrafish and examined their responses following PSNP exposure. In sod3a mutant larvae, tissue accumulation of PSNPs was higher than in wild-type (WT), and this was associated with elevated oxidative stress, enhanced cell death, and abnormalities in intestinal function and immune responses. Collectively, these observations reveal the functional importance of SOD3 during PSNP-induced oxidative stress and provide new insight into extracellular antioxidant mechanisms that mitigate PSNP-induced toxicity.

keywords:
superoxide dismutase 3; nanoplastics; oxidative stress; cell death; intestinal function and immune response

4-68

Biochemistry & Molecular Biology; Chemistry, Multidisciplinary

Synthesis and Biological Evaluation of Novel Ramalin Derivatives as Multi-Target Agents for Alzheimer’s Disease

Kim, Tai Kyoung., Hong, Ju-Mi., Cho, Yongeun., Jeon, Yeji., Cho, Heewon., Lee, Jeongmi., Kim, Jaewon., Kim, Kyung Hee., Kim, Il-Chan., Han, Se Jong., Oh, Hyuncheol., Jo, Dong-Gyu. and Yim, Joung Han.
Molecules. 2025. 30(9).
doi: 10.3390/molecules30092030.

Alzheimer’s disease (AD) is a complex neurodegenerative disorder characterized by cognitive decline, oxidative stress, neuroinflammation, amyloid-beta ($A\beta$) accumulation, and tau protein hyperphosphorylation. In this study, we synthesized novel Ramalin derivatives and evaluated their therapeutic potential against AD, focusing on antioxidant, anti-inflammatory, and neuroprotective activities. RA-2OMe, RA-4OMe, RA-2CF3, and RA-4OCF3 showed strong antioxidant effects, while RA-2OMe exhibited potent NO and NLRP3 inhibition (~20%). RA-NAP, RA-PYD, and RA-2Q showed moderate anti-inflammatory activity. BACE-1 inhibition was significant in RA-3CF3, RA-NAP, and RA-PYD, with IC₅₀ values lower than that of positive control, indicating greater inhibitory potency. RA-NAP and RA-PYD effectively inhibited both $A\beta$ and tau aggregation, highlighting their multi-target

potential for AD therapy. These findings indicate that Ramalin derivatives exhibit potential for multi-target activity in AD treatment. However, further studies on their pharmacokinetics, in vivo efficacy, and long-term safety are required to confirm their therapeutic applicability.

keywords:
Alzheimer’s disease; Ramalin derivatives; antioxidant activity; anti-inflammatory activity; BACE-1 inhibition; tau aggregation; multi-target therapy

4-69

Biotechnology & Applied Microbiology; Genetics & Heredity

The complete plastome of the Antarctic moss *Andreaea regularis* (Andreaeaceae) and its comparative analyses within Bryophyta

Sulaiman, Syahril., Lee, Hyodong., Min, Kyungwon., Lee, Jungeun., Yoon, Young-Jun., Lee, Jun Hyuck. and Lee, Hyoungseok.
Bmc Genomics. 2025. 26(1).
doi: 10.1186/s12864-025-11854-w.

Background: Andreaeopsida represents a distinct group of nonperistomate mosses, characterized by its phylogenetic position as a sister to peristomate species. However, plastome data for this lineage remains scarce, limiting our understanding of its genomic features and the evolution of plastome within Bryophyta. To bridge this gap, we sequenced the plastome of *Andreaea regularis*, a prominent species within the Andreaeopsida, found in Antarctica. This study aims to characterize the plastome of *A. regularis* and compare its features across nonperistomate and peristomate moss lineages, focusing on phylogenetic placement, plastome characteristics variations, and potential selection pressures. **Results:** The assembled plastome of *A. regularis* spans 135,217 bp with 30.3% GC content and 122 annotated genes. Phylogenetic analysis confirms the position of *A. regularis* among the nonperistomate mosses, forming a sister group to the peristomate lineage. Comparative analysis reveals a reduction pattern in plastome size, GC content, and protein-coding gene (PCG) content along the evolutionary trajectory from nonperistomate mosses to peristomate mosses, with *A. regularis* exhibiting intermediate characteristics. This pattern is

mirrored by structural variation in the large single-copy (LSC) region, where *A. regularis* retains more PCGs and exhibits lower deletion rates than peristomate species but shows signs of genome contraction relative to nonperistomate mosses. Correlation analysis further indicates that total plastome size and GC content are most strongly associated with LSC length ($r = 0.994$) and GC content ($r = 0.999$), respectively, suggesting that LSC variation is closely linked to plastome structural differences among mosses. Purifying selection is prevalent across genic regions in mosses, while codon usage patterns remain minimally affected by mutational pressure. The genes *rpoC2* and *ndhF* exhibit dynamic evolution, marked by elevated nonsynonymous substitution rates, high nucleotide diversity, and numerous diagnostic sites. Additionally, positively selected residues in these genes, alongside those in *rbcL*, indicate potential evolutionary pressures in *A. regularis*. **Conclusions:** Altogether, this study establishes a critical genomic reference for Andreaeopsida, advances our understanding of nonperistomate-peristomate plastome evolution, and highlights the intricate nucleotide variation underlying plastome diversity and evolutionary differentiation in mosses.

keywords:
Antarctica; Bryophyte; Chloroplast; Evolutionary pressure; Moss

4-70

Pharmacology & Pharmacy

The neuroprotective and anti-neuroinflammatory effects of ramalin synthetic derivatives in BV2 and HT22 cells

Liu, Zhiming., Yoon, Chi-Su., Lee, Hwan., Kim, Eunae., Yim, Joung Han. and 3 others.
Biochemical Pharmacology. 2025. 231.
doi: 10.1016/j.bcp.2024.116654.

Ramalin, a strong antioxidant isolated from Antarctic lichens, has been shown to have potential therapeutic effects in the treatment of Alzheimer’s disease. However, this compound is readily degraded in aqueous solutions, which restricts its development as a therapeutic agent. With a view toward addressing this problem, in this study, we modified the structure of ramalin to obtain more stable compounds and attempted to identify a derivative with the strongest neuroprotective properties. We synthesized a total of 20

ramalin derivatives, among which, RA-2 N was demonstrated to have the best neuroprotective effects, not only inhibiting inflammation in BV2 cells but also inhibiting inflammation-induced HT22 cell apoptosis in BV2-HT22 co-culture models. Moreover, we established that these effects were associated with an inhibition of the nuclear translocation of nuclear factor kappa-B (NF-κB). Our findings in this study revealed that the synthesis of ramalin derivatives is an effective approach for stabilizing this compound for therapeutic purposes. Given its modified structure, the RA-2 N derivative can inhibit inflammation and protect nerve cells, and thus indicate its potential application as a drug for treating neurodegenerative diseases.

keywords:
Ramalin derivative; NF-κB; Neuroprotection; Anti-neuroinflammation; BV2-HT22 co-culture models

4-71

Plant Sciences

Transcriptomic responses of Antarctic plants to in situ warming: uncovering molecular mechanisms behind physiological adjustments

Min, Kyungwon., Sulaiman, Syahril., Lee, Jungeun., Bravo, Leon A., Saez, Patricia L. and Lee, Hyoungseok.
Annals of Botany. 2025. 136(3): 529–542.
doi: 10.1093/aob/mcaf108.

Background and Aims: Previous studies using open-topped chambers to simulate warming in Antarctic field conditions have shown distinct physiological responses between the two Antarctic vascular plants *Colobanthus quitensis* and *Deschampsia antarctica*. *Colobanthus quitensis* exhibited significantly increased photosynthetic capacity and growth during in situ warming conditions, whereas *D. antarctica* showed no differences in these parameters. To understand the differences in ecological strategies of these plants in response to climate change, it is important to elucidate the molecular mechanisms underlying physiological responses. **Methods:** Transcriptome profiling was performed on plants from open-topped chambers and a control open area on King George Island, after three growing seasons. Differential gene expression was analysed using RNA sequencing,

followed by Gene Ontology and Kyoto Encyclopedia of Genes and Genomes pathway enrichment analyses to identify key biological processes affected by in situ warming. **Key Results:** *Colobanthus quitensis* exhibited significant upregulation of photosynthesis-related genes, including aquaporins, carbonic anhydrases and Rubisco activase, enhancing CO₂ diffusion and assimilation. Conversely, *D. antarctica* showed downregulation of photosynthetic pathways but upregulation of genes related to flowering, including flowering-promoting factor and phytochrome-regulatory proteins. Both species showed molecular signatures suggesting reduced freezing tolerance in warming conditions, potentially increasing their susceptibility to frost damage. **Conclusions:** The results indicate distinct ecological strategies between the two plants in response to *in situ* warming. *Colobanthus quitensis* enhances its photosynthetic efficiency, whereas *D. antarctica* appears to accelerate its reproductive phase rather than focusing on growth. These findings contribute to our understanding of how Antarctic plants might respond to ongoing climate changes, with potential implications for their future resilience to extreme environmental conditions.

keywords:
Antarctic; aquaporin; carbonic anhydrase; *Colobanthus quitensis*; *Deschampsia antarctica*; open-topped chamber; Rubisco activase; transcriptome; warming

4-72

Plant Sciences

Trends and Challenges in Plant Cryopreservation Research: A Meta-Analysis of Cryoprotective Agent Development and Research Focus

Kang, Pilsung., Kim, Sung Jin., Park, Ha Ju., Han, Se Jong., Kim, Il-Chan., Lee, Hyoungseok. and Yim, Joung Han.
Plants-Basel. 2025. 14(3).
doi: 10.3390/plants14030447.

The stable long-term preservation of plant cells is crucial for biopharmaceuticals and food security. Therefore, the long-term cryopreservation of plant cells using a cryoprotective agent (CPA) is a crucial area of study. However, research on low-toxicity CPAs remains limited. We analyzed 1643 abstracts

related to plant-cryopreservation (PCP) research published from 1967 to May 2023, spanning 56 years, from academic citation databases, with the search conducted in May 2023. Grouping these abstracts by five-year intervals revealed an increase in PCP papers until 2015, followed by a decline in the 2020s. In order to confirm the declining trend, we performed text-mining analysis using the Latent Dirichlet Allocation (LDA) algorithm, which identifies underlying topics across diverse documents to aid decision-making and classified the abstracts into three distinct topics: Topic 1, “Seed bank”; Topic 2, “Physiology”; and Topic 3, “Cryopreservation protocol”. The decline, particularly in “Cryopreservation protocol” research, is an important observation in this study. At the same time, this decrease may be due to the limited scope of Topic 3. However, we expect improvements with the development of new CPAs. This expectation is based on numerous ongoing studies focused on developing new CPAs for the cryopreservation of various animal and medical cell lines, with particular attention on polysaccharides as components that could reduce the required concentrations of existing CPAs.

keywords:
plant cryopreservation; cryoprotective agent; plant tissue culture; exopolysaccharide; polar regions; text-mining; meta-analysis

4-73

Plant Sciences; Chemistry, Medicinal

Two new compounds from *Apiospora xenocordella* culture medium and their inhibitory effects on TNF-α-induced ROS generation and MMP-1 secretion

Kwon, Haeun., Ann, Hee Woon., Lee, Jin Su., Kwon, Jaeyoung., Park, Keunwan., Guo, Yuanqiang., Hwang, Bang Yeon., Kim, Jae-Jin., Yim, Joung Han., Kim, Il-Chan. and 3 others.
Phytochemistry Letters. 2025. 65: 38–43.
doi: 10.1016/j.phytol.2024.11.005.

A new cytosporin derivative (1) and a new phenolic compound (2), together with cytosporin D (3), were isolated from an EtOAc extract of *Apiospora xenocordella* culture medium. The isolation workflow was guided by a Molecular Networking-based dereplication strategy. The chemical structures of the

new compounds were determined by using MS and NMR spectroscopic techniques, and the absolute configurations were established by the modified Mosher’s method and quantum chemical calculation of electronic circular dichroism. UV radiation activates pro-inflammatory cytokines, such as TNF-α, a major contributor to skin aging through ROS generation and MMP-1 secretion. Cytosporin D (3) exhibited the inhibition of TNF-α-induced ROS and MMP-1. UV radiation activates pro-inflammatory cytokines including TNF-α which is a major contributor to skin aging through reactive oxygen species (ROS) generation and matrix metalloproteinase-1 (MMP-1) secretion. Cytosporin D (3) exhibited moderate inhibition against TNF-α-induced ROS and MMP-1. This compound docked computationally into the active site of MMP-1 (–5.9 kcal/mol). Compound 1, though not tested due to limited quantity, showed a docking simulation result (–6.0 kcal/mol) ~ cytosporin D (3), indicating potential activity.

keywords:
Apiospora xenocordella; Cytosporin Z; Apiospin; Molecular Networking; ROS generation; MMP-1 secretion

4-74

Ecology; Marine & Freshwater Biology; Microbiology

Vertical Structure and Functional Diversity of Microbial Communities in the Ross Sea, Antarctica

Yeo, In-Cheol., Shim, Kyu-Young., Min, Jun-Oh., Kim, Jeong-Hoon., Ha, Sun-Yong. and Jeong, Chang-Bum.
Microbial Ecology. 2025. 88(1).
doi: 10.1007/s00248-025-02604-2.

The Ross Sea, Antarctica, encompasses distinct water masses, each characterized by unique physicochemical conditions influencing microbial community composition and functional diversity. This study examined microbial communities across five stations covering various water masses, including Antarctic Surface Water (AASW), Circumpolar Deep Water (CDW), and Shelf Water (SW). Despite limited horizontal variability, significant vertical structuring was observed, potentially driven by vertical microbial dispersal from surface waters. Surface communities exhibited lower alpha diversity due to abundant labile organic matter favoring fast-growing heterotrophic taxa,

whereas deeper communities displayed increased microbial richness, reflecting adaptation to more refractory organic matter. Functional diversity revealed distinct depth-related patterns, with metabolic pathways associated with organic matter predominantly enriched in surface layers. Concurrently, rare taxa became more abundant with depth, emphasizing their potential role as keystone organisms in deep-ocean nutrient cycling. These findings highlight the critical role of vertical microbial connectivity and organic matter composition in shaping microbial community structure and functional specialization, contributing significantly to our understanding of microbial-mediated biogeochemical processes in polar marine ecosystems.

keywords:
Antarctica; Ross Sea; Microbiome; Vertical connectivity; Organic matter cycle

4-75

Plant Sciences; Environmental Sciences

Vulnerability of Brassica oleracea L. (cabbage) grown in microplastic-contaminated soil to extreme climatic events associated with freeze-thaw

Min, Kyungwon., Kim, Gyuwon., Lee, Hyoungseok. and 3 others.
Environmental and Experimental Botany. 2025. 232.
doi: 10.1016/j.envexpbot.2025.106110.

Climate change and environmental pollution have increased the frequency and severity of extreme weather events, exposing plants to multifactorial stress conditions that are poorly understood. While extensive research has explored plant responses to individual stress factors, the impact of combined stresses—such as microplastic (MP) contamination and freeze–thaw cycles—remains largely unexamined. This research investigated how soil microplastic pollution affects the freezing tolerance of cabbage (*Brassica oleracea* L.), a crop vulnerable to unexpected frosts. Seedlings were grown in soils containing varying MP concentrations (0 %, 2 %, 5 %, and 10 % w/w), and their physiological responses to freezing events (–2.5°C and –3.5°C) were assessed. Our findings revealed that although MP particles were not detected in leaf tissues, MP contamination significantly reduced freezing tolerance in a

dose-dependent manner. Plants grown in 10 % MP-treated soil exhibited higher membrane damage, as indicated by increased ion leakage and malondialdehyde levels, and showed more severe oxidative stress, with elevated superoxide (O₂^{•–}) and hydrogen peroxide (H₂O₂) accumulation. These stress responses corresponded with suppressed antioxidant enzyme activities, including catalase (CAT), ascorbate peroxidase (APX), and superoxide dismutase (SOD). Principal component analysis (PCA) demonstrated distinct physiological patterns between control and MP-treated plants, emphasizing the disruptive impact of MP pollution on stress resilience. This study provides the first empirical evidence that soil microplastic contamination compromises plant tolerance to freeze–thaw cycles, highlighting an overlooked risk to crop performance in changing environmental conditions and calling for further research into the long-term ecological consequences of terrestrial MP pollution.

keywords:
Freezing thaw stress; Microplastics; Cabbage; Extreme climate events; Reactive oxygen species

Part 05.

Policy&Technology

5-1

Materials Science, Multidisciplinary

An architecting binder derived from Antarctic red algae to accelerate sulfur redox kinetics in Li-S batteries

Jung, Han Young., Jung, Hyun Wook., Koo, Man Hyung., Hong, Tae Hwa., Kim, Dong Jun., Lee, Jung Seok., Lee, Yoon Hak., Jang, Hyeonji., Kim, Jin-Hyoung., Kim, Sanghee., Heo, Eun Jin., Lee, Seulah., Youn, Ui Joung. and Lee, Jung Tae.
Materials Today. 2025. 83: 231–241.
doi: 10.1016/j.mattod.2025.01.006.

Volume changes during charge/discharge cycles can lead to substantial cracking, disrupting electron and ion transfer channels, and hindering the performance of lithium–sulfur (Li–S) batteries. Binders are crucial for mitigating these issues because they preserve the structural integrity of electrodes and ensure reliable operation. Herein, this study presents the first report of a hybrid carrageenan, Antarctic macroalgae *Curdiea racovitzae*–derived polysaccharide (CRP), consisting of a diverse–blocked copolymer including kappa, iota, mu, nu carrageenans, and porphyran as Li–S battery binders. CRP prevents binder agglomeration and enables the electrode to form a uniform 3D–network structure reminiscent of an ant tunnel, enhancing the electrolyte permeability and utilization of the sulfur species. Additionally, the abundant functional groups in CRP, such as sulfate and hydroxyl groups, facilitate efficient Li– ion transport. By leveraging these properties, the CRP–based sulfur electrode achieves a high initial capacity of similar to 1500 mAh g^{–1} at 0.1C, approximately 90 % of the theoretical capacity, and demonstrates superior cycle stability at 1C. Moreover, the Li₂S nucleation rate was nearly 100 times higher compared to the PVDF–based sulfur electrode. The incorporation of a sustainable CRP binder in Li–S batteries marks a notable breakthrough, paving the way for future

developments in the battery field.

keywords:
Li–S batteries; Architecting binder; Biomass; Multifunctional natural copolymer; Antarctic red algae

5-2

Analysis of the Science-Policy Interface and Political Influences in Antarctic Governance: Implications for Marine Life Science Research

Kim, Hyung Joon., Seong, Yeong Bae., Kim, Jeong-Hoon. and Park, Hyun.
Journal of Marine Life Science. 2025. 10(2): 90–105.
doi: 10.23005/ksmls.2025.10.2.90.

Antarctica has emerged as a key region for addressing global environmental change and ensuring the sustainable future of humanity. Concurrently, the significance of evidence–based policymaking at the Science–Policy Interface, including its political dimensions, has grown in Antarctic governance. This study examines the operational mechanisms of Antarctic governance through the lens of the science ? policy interface and political dynamics, discussing the roles of marine bioscientists and the implication for policy. Recent policy proposals, such as the establishment of Marine Protected Areas and the designation of emperor penguins as a specially protected species, have failed to reach a consensus due to limited scientific evidence, economic interests, and political conflicts. These cases exemplify the politicization of science, illustrating how knowledge gaps, scientific uncertainty, and the selective use of data can delay policy decisions. Accordingly, Antarctic marine bioscience should extend its role beyond providing empirical evidence to serving as a foundation for effective policy frameworks and informed decision–making. To this end, marine life scientists should broaden their engagement with policy issues within the Antarctic governance system, strengthen science ? policy communication, and actively participate in international collaborative mechanisms such as SCAR’s Ant–ICON, CCAMLR’s CEMP, and MEASO, thereby advancing the Antarctic Treaty’s core principle of contributing science to the common interests of mankind and enhancing the effectiveness of policy implementation.

keywords:
Antarctic governance; Science ? Policy Interface; Politics; Marine Life Science Research; Marine Protected Area; Emperor Penguin

5-3 **Engineering, Environmental; Engineering, Chemical**

Biochar utilization in thermochemical biodiesel production from perilla seed

Lee, Taewoo., Park, Gyeongnam., Cha, Hoyeon., Nam, Hyungseok., **Kim, Han-Woo.** and Kwon, Eilhann E.
Chemical Engineering Journal. 2025. 525.
doi: 10.1016/j.cej.2025.170661.

Transportation sector faces environmental challenges due to carbon dioxide emissions from the heavy use of fossil fuels in internal combustion engines. Biodiesel (BD) has emerged as a carbon-neutral fuel option due to its seamless compatibility with petroleum-derived diesel. However, BD production suffers from inefficient carbon utilization, as the selective use of lipids in biomass remains unused waste. To address this issue, this study proposes a thermochemical platform for zero-waste BD production using perilla seed as a model feedstock. In this approach, defatted perilla seed, remaining after lipid extraction, is converted into biochar, which is then utilized as a catalyst to expedite the kinetics of transesterification. Production of defatted seed biochar (DSB) was conducted under four different pyrolysis temperatures of 400, 500, 600, and 700 degrees C. Characterizations of the produced biochars revealed that DSB produced at 600 degrees C (DSB600) exhibited the highest surface porosity with concentrated base metals, making it ideal for catalytic applications. When applied to thermally-induced transesterification, DSB600 demonstrated superior catalytic performance with a BD yield of 98.27 wt% at 250 degrees C, surpassing the results from biochars produced at other temperatures. To evaluate the practical applicability, the properties of perilla-derived BD was theoretically estimated against standardized specifications for pure BD. However, perilla BD failed to meet the required standards due to a high content of unsaturated components. In response to this limitation, its blending with saturated BD from other feedstocks, such as palm, was explored. This optimal blending composition of perilla BD to palm BD was estimated to be 20–

50 wt%. This strategic approach helps effectively complement the shortcomings of both BDs while enhancing the viability of perilla BD for practical applications.

keywords:
Biorefinery; Transesterification; Biodiesel production; Perilla seed; Pyrolysis; Biochar

5-4

Challenges to the Antarctic Treaty System in the Era of Climate Crisis and Hegemonic Competition: Korea's Role

Kim, Ji hee., Kim, Jeong-Hoon. and **Seo, Won-Sang.**
Ocean and Polar Research. 2025. 47: 1–14.
doi: 10.4217/opr.2025006.

The Antarctic Treaty System (ATS) has evolved over the past 60 years, beginning with the Antarctic Treaty itself, overcoming various internal and external challenges. However, since the Protocol on Environmental Protection came into effect, the adoption of binding environmental protection measures has been significantly delayed, raising concerns and distrust regarding the governance capacity of the ATS. Amid the global climate crisis, the delay in urgent environmental protection measures for safeguarding the Antarctic environment can be attributed to certain consultative parties exercising their veto power annually. This is rooted in the U.S.–China global rivalry extending to Antarctica, conflicts among consultative parties within the system, and different views held by countries like China and Russia on protection proposals by claimant states whose territorial claims were frozen under the Antarctic Treaty. These factors are destabilizing the foundations of the ATS, heightening fears that the treaty may disband due to external pressures and internal conflicts. In the Ross Sea, where the Republic of Korea's Jang Bogo Station, the United States' McMurdo Station, New Zealand's Scott Base, and Italy's Mario Zucchelli Station are already operational, China established its fifth Antarctic station earlier this year. This development has transformed the Ross Sea into a strategic geopolitical hotspot for competing global powers. With the global climate crisis and China's increasing presence intensifying the region, Korea, which has expanded its Antarctic activities, now faces a critical juncture to reflect on its strategic direction for Antarctic activities that serve both national interests and the advancement of the ATS.

keywords:
Antarctic governance; consensus decision-making; protection measure; Ross Sea; collaboration

5-5 **Engineering, Environmental; Environmental Sciences**

Distinguishing between extractable and leachable contents of styrene oligomers in various polystyrene consumer products: Towards environmentally realistic scenarios

Tian, Zhexi., Kim, Seung-Kyu. and **Kim, Kitae.**
Journal of Hazardous Materials. 2025. 487.
doi: 10.1016/j.jhazmat.2025.137190.

Plastic additives' environmental impacts remain insufficiently understood due to knowledge gaps in their bioavailability, despite growing concerns from increased plastic use and waste. Additives that are non-covalently bound but strongly interact with polymers can be extractable but not leachable, thus non-bioavailable. Nevertheless, most studies have not distinguished between extractable (EC) and leachable content (LC) in plastic additives. We quantified the EC and LC of styrene oligomers (SOs) in polystyrene (PS) by applying the selective solvent compatibility of PS-dissolution in dichloromethane for EC and swelling in *n*-hexane for LC. Significant differences were found between EC and LC of SOs in 28 widely consumed PS products and across three PS types-expanded PS (EPS), extruded PS (XPS), and solid PS. EPS showed lower EC and LC values and fewer SO isomers. LCs were only 32 % (EPS), 84 % (XPS), and 72 % (solid PS) of ECs, suggesting bioavailable fractions may be overestimated if only EC is considered. We estimate that 3.3 MT of PS-incorporated SOs, with 76 % in leachable forms, have entered the environment, but much may still remain in PS debris. Distinct isomer ratios and high non-leachable fractions in EPS suggest that SOs could serve as effective tracers for distinguishing and quantifying invisible EPS-origin particles in beach sediments. This study underscores the need to differentiate EC from LC for environmentally realistic risk assessment and source identification.

keywords:
Plastic additives; Styrene oligomers; Bioavailability; Leachable fraction; Hansen solvent solubility parameter; Risk assessment; Source identification

5-6 **Engineering, Environmental; Environmental Sciences**

Efficient and stable copper tungstate catalyst for water treatment with peroxymonosulfate: Effect of synthetic pH, primary oxidant, and practical feasibility

Tran, Khen Duy., **Ahn, Yong-Yoon., Kim, Bomi., Kim, Kitae.** and 2 others.
Journal of Hazardous Materials. 2025. 488.
doi: 10.1016/j.jhazmat.2025.137482.

In this study, copper tungstate (CuWO₄) nanoparticles, which are highly efficient and stable catalysts for water treatment, were synthesized via a hydrothermal method under various pH conditions. CuWO₄ synthesized at pH 10 (CuWO₄@10) exhibited the highest degradation efficiency and the lowest metal ion leaching. In the presence of CuWO₄@10 (0.5 g/L) and peroxymonosulfate (PMS, 1 mM), 4-chlorophenol (4-CP, 100 μM) was completely degraded within 5 min, and the total metal ion leaching concentration after 4 h was only 10.2 μM. The catalytic activity of CuWO₄ for 4-CP degradation was 4.7–99.0 times greater than that of CuO catalysts. This enhanced performance is attributed to the presence of W, which increases the surface area and reduces charge transfer resistance. Based on the results of radical-quenching experiments, solvent exchange experiments, PMS decomposition measurements, electron paramagnetic resonance spectroscopy, and Raman spectroscopy, high-valent copper (Cu(III)) was identified as the primary oxidant responsible for degradation in the CuWO₄/PMS system. The CuWO₄/PMS system rapidly degraded various phenolic compounds, and its degradation efficiency remained consistent across repeated uses of the CuWO₄ catalyst. Degradation in groundwater also occurred efficiently in the CuWO₄/PMS system. This study provides valuable insights into the development of practical PMS-based water treatment processes.

keywords:
Bimetallic oxide; pH adjustment; Peroxymonosulfate; High-valent copper; Phenolic compound

5-7

Extreme Cold-region Network Design and Reliable Operations Scenarios for Limited Power-based Extreme Environment Data Collection

Hwang, A. Ri., Yum, Sun-Ho., **Park, Soo-Hyun.** and Yoon, Dong-Jin.
Journal of the Institute of Electronics and Information Engineers. 2025. 62(7): 3–23.
doi: 10.5573/ieie.2025.62.7.3

Today, polar regions such as the Arctic and Antarctic collect a wealth of data on climate, geology, oceanography, ecology, and more, and are utilized in a variety of studies. These data can be collected directly by researchers or transmitted via satellite communication, but there are many limitations due to the characteristics of extreme environments such as snowfall and strong winds. In this paper, we derive the requirements for building and operating network infrastructure in extreme environments, analyze the components and interfaces that meet them, and propose operational scenarios for stable data transmission. We also propose a simulation model that can calculate the traffic and data loss rates that may occur when operating a network in extreme environments, and analyze the traffic and data loss rates in each operational scenario. We propose a reliable data transmission scenario that considers network lifetime, traffic generation, and data loss rate in extreme environments.

keywords:
Extreme cold region; Network communication in an extreme cold region; Limited power; Network requirements; Extreme cold region network design; Reliable operations scenarios

5-8

Goeconomic Restructuring of Russia’s Arctic Diplomacy - Focusing on the Changing Relations with China and India Based on Russia’s Arctic Policy –

Park, Jongkwan. and **Seo, Hyunkyo.**
Slavic Studies. 2025. 41(4): 1–31.
doi: 10.17840/irsprs.2025.41.4.001.

This study analyzes the changes in Russian foreign policy stemming from the international relations crisis since 2013. Specifically, it analyzes Russia’s stance toward non-Arctic states in the Arctic, as reflected in Russian foreign policy documents and diplomatic actions, particularly the expansion of economic and security cooperation based on economic cooperation with Eastern countries such as China and India. The Arctic is crucial to Russia’s foreign policy direction. According to Russian foreign policy strategic documents, the importance of the Arctic has increased over time. In particular, amidst the confrontation with the United States and NATO, Russia’s stance toward non-Arctic states shifted from lukewarm to friendly. This shift stemmed from the annexation of Crimea in 2014 and the Russian military invasion of Ukraine in 2022. In other words, the economic sanctions imposed against Russia by Western countries, including the United States and the EU, became a major turning point in Russia’s foreign policy, focusing on the Arctic.

keywords:
Arctic; Russian Arctic; Russian Arctic foreign policy; Russian Arctic policy; non-Arctic countries

5-9

Historical Review & Implications of Korea’s Arctic Sea Route Policy

Seo, Hyunkyo. and Park, Jongkwan.
Korean Journal of Siberian Studies. 2025. 29(4): 65–99.
doi: 10.22892/ksc.2025.29.4.03.

After gaining observer status to the Arctic Council in 2013, South Korea established its first Arctic policy, named The 1st Masterplan for Korea’s Arctic Policy,” in December of the same year. This included tasks related to the Arctic Sea Route, marking the first step toward establishing a policy for the Arctic Sea Route. Subsequently, in 2018 “The 2nd Masterplan for Korea’s Arctic Policy (2018–2022),” embraced the policy-tasks related with the Arctic Sea Route, which had significance as an implementation tasks for the Moon Jae-in administration’s Nine-Bridges Strategy in 2017. However, both Masterplans were non-statutory, limiting their ability to implement and drive policies related to the Arctic sea route. In 2021, the government enacted the Polar Activities Promotion Act and, based on Article

6 of the Act, established and announced the 1st Masterplan for Polar Activities Promotion (2023–2027), which was a statutory Masterplan. Starting with this Masterplan, the Arctic sea route policy was the agenda of comprehensive concept, from the Arctic ports as a maritime logistics route to infrastructure construction such as shipbuilding, ports construction, and relevant-technologies development. Currently, The Lee Jae-myung administration is promoting the “Arctic sea route” agenda as a priority policy-task, putting it at the forefront of its 123 major national policy agendas. This study analyzed domestic & international prior research trends on the Arctic Sea Route and analyzed domestic Arctic Sea Route policies by era, from the 1st Masterplan for Korea’s Arctic Policy to the Lee Jae-myung administration’s 123 major national policy agendas. Furthermore, based on the Arctic Policy Model (2019), the study reclassified the sub-tasks within the ‘Arctic Sea Route’ part of 123 major national policy agenda and proposed additional sub-tasks in areas such as international cooperation, infrastructure development, and scientific research. This study presented directions for identifying sub-tasks for the development of the National Arctic Sea Route Masterplan in the future, and concluded by proposing a desirable Arctic Sea Route policy direction.

keywords:
‘The 1st Masterplan for Korea’s Arctic Policy’; The 2nd Masterplan for Korea’ Arctic Policy; The 1st Masterplan for the Polar Activity Promotion; Northern Sea Route; 123 national tasks by LEE Jae-myung’s Administration

5-10 **Engineering, Environmental; Environmental Sciences**

Photo-Fenton mineralization of aquatic organic pollutants in visible-light-driven photocatalysis: Revisiting Fe³⁺ reduction and noble metal necessity

Le, Thao Thi., **Ahn, Yong-Yoon., Kim, Kitae.** and 2 others.
Journal of Hazardous Materials. 2025. 497.
doi: 10.1016/j.jhazmat.2025.139589.

The photo-Fenton process is an advanced oxidation technique that utilizes electrons photogenerated from a photocatalyst to activate hydrogen peroxide (H₂O₂), forming highly reactive

hydroxyl radicals (center dot OH) capable of rapidly degrading organic pollutants. While noble metal co-catalysts are often introduced to facilitate charge separation and promote H₂O₂ activation, their use can increase the cost and complexity. In this study, hierarchically porous tungsten oxide (WO₃) demonstrated enhanced photo-Fenton performance without the need for noble metals owing to its larger surface area and strong ferric ion (Fe³⁺) adsorption capacity. This facilitated efficient electron transfer from WO₃ to Fe³⁺, promoting rapid ferrous ion (Fe²⁺) formation and subsequent center dot OH generation. Compared to commercial and unstructured WO₃, porous WO₃ achieved faster and more complete mineralization of isopropanol, a model organic pollutant. The system also exhibited broad reactivity toward various phenolic and non-phenolic contaminants, confirming its non-selective degradation capability. These findings highlight the importance of catalyst surface properties over noble metal loading in photo-Fenton re-actions and present a promising strategy for coupling electrochemically produced H₂O₂ for sustainable water treatment applications.

keywords:
Tungsten oxide; Iron anchoring sites; Noble metal-free catalysis; Photo-Fenton reaction; Visible-light photocatalysis

5-11 **Engineering, Environmental; Environmental Sciences**

Photooxidation of Natural and Waste Cr(III)-Bearing Hydroxides in Water and Ice: Cr(III)-O2 Complex-Mediated Oxidation and the Effect of Natural Organic Matter

Hu, Yi., Du, Juanshan., **Chung, Hyun Young., Kim, Kitae.** and 2 others.
Environmental Science & Technology. 2025. 59(36): 19502–19512.
doi: 10.1021/acs.est.5c09710.

The photooxidative dissolution of Cr(III)-bearing hydroxides (Cr(OH)₃ and FexCr_{1-x}(OH)₃) is proposed as a potential abiotic source of Cr(VI) in environments. Compared to the dark oxidation of Cr(OH)₃ by O₂, photoirradiation enhanced Cr(VI) production in both aqueous and frozen solutions. In the presence of natural organic matter (NOM), the photoproduction of Cr(VI) was significantly promoted in aqueous solution but

hindered in frozen solution. Photosensitized NOM induced the production of H₂O₂ that played the dual roles of enhancing Cr(OH)₃ oxidation in aqueous solution and accelerating Cr(VI) reduction in frozen solution. The in situ generated Cr(VI) in the Cr(OH)₃/NOM/UV system was gradually accumulated during the repeated cycles of aqueous–frozen phase transitions and light–dark variations, which confirms that the stable Cr(OH)₃ can be a source of natural Cr(VI) under realistic environmental conditions. The photooxidative dissolution of Cr(OH)₃ is proposed to involve the complex formation between dissolved Cr(OH)₄– and O₂, which subsequently undergoes the photoinduced charge transfer, resulting in the oxidation of Cr(III) to Cr(VI) with the concurrent reduction of O₂ to H₂O₂ via center dot O₂–. A similar mechanistic behavior was also observed with Fe_xCr_{1–x}(OH)₃ (x = 0.3, 0.5, and 0.7) for the photooxidative production of Cr(VI). This study unveils an underappreciated pathway of Cr(VI) production from natural and waste Cr(III)–bearing hydroxides.

keywords:

Cr(VI) generation; Cr(III)–bearing hydroxide; Cr(III)–Cr(VI) redox process; chemical reactions in ice

5-12 Spectroscopy

Spectroscopic characterization of phenol in frozen aqueous solution and on the ice surface

Garncarzova, Marie., Vesely, Luka., **Kim, Bomi.**, **Kim, Kitae.** and Heger, Dominik.
Spectrochimica Acta Part a–Molecular and Biomolecular Spectroscopy. 2025. 335.
doi: 10.1016/j.saa.2025.125948.

Phenol is one of the omnipresent pollutants in the environment, frequently detected in ambient air, water, soil, snow, and ice. Due to its low aqueous reactivity and inability to undergo direct photolysis under typical tropospheric conditions, phenol can be widely distributed and accumulated in the environment for an extended period of time. However, the reactivity of phenol can be influenced by a number of factors, including temperature, pH, and phase transitions. The present study examines the impact of the ice matrix and ice surface on the photophysical properties of phenol via UV–VIS, fluorescence,

and Raman spectroscopies. We demonstrate that the freezing of an aqueous solution results in the vitrification or crystallization of the freeze–concentrated solution. The latter case is accompanied by a bathochromic shift of the absorption spectrum above 290 nm. The most pronounced red–shifts were obtained for deprotonated and crystalline samples, which suggests that direct photolysis under tropospheric conditions would be significantly enhanced in these cases. The study further demonstrates the difference in the molecular arrangement in freeze–concentrated solutions as compared to the surface of Ih ice.

keywords:

Freeze concentrated solution; Organic pollutants; Crystallization; Bathochromic shift; Photodegradation; Absorption spectra; Photophysics

5-13 Engineering, Environmental; Environmental Sciences

Sustainable mineralization of bisphenol A via iron-oxide-fortified manganese catalysts: Integrating radical and nonradical pathways for advanced wastewater treatment

Le, Thao Thi., Hoang, Van Chinh., **Ahn, Yong–Yoon.**, **Kim, Kitae.** and 3 others.
Journal of Hazardous Materials. 2025. 492.
doi: 10.1016/j.jhazmat.2025.138047.

Nanoparticulate manganese dioxide (MnO₂) was integrated into a ferric oxide (Fe₂O₃) framework via a coprecipitation technique followed by thermal annealing, yielding a porous composite structure enriched with surface pores and microcracks. The Mn:Fe stoichiometry played a critical role in determining the crystalline architecture, catalytic performance, and stability of the composites. In dark conditions, the degradation of Bisphenol A (BPA) through peroxydisulfate (PDS)–mediated electron transfer did not achieve complete mineralization. Under UV irradiation, however, the composite facilitated near–complete BPA mineralization due to a synergistic interaction between radical generation and electron transfer processes. Notably, nonradical mechanisms predominantly governed BPA degradation, with the PDS–MnO₂ interaction being central to its efficiency. The Fe₂O₃ matrix improved structural stability,

significantly reducing manganese ion leaching. Specifically, MnFe–12 (Mn:Fe 1:2) exhibited a 2200–fold reduction in Mn dissolution compared to bare MnO₂. In situ X–ray absorption spectroscopy revealed that radical–mediated processes elevated the oxidation state of Mn ions, while Fe ions remained unchanged. The study highlights the importance of integrating radical and nonradical pathways to achieve efficient and sustainable degradation of persistent pollutants, offering insights for the rational design of advanced oxidation systems with enhanced structural integrity and catalytic efficiency.

keywords:

Persulfate; UV; Radical pathway; Nonradical process; Bisphenol A

5-14 Chemistry, Physical; Materials Science, Coatings & Films; Physics, Applied; Physics, Condensed Matter

Synergistic effects of ionic liquid integrated superhydrophobic composite coatings on anti-icing properties

Patil, Aravind H., Trinh, Ngoc Le., **Do, Hackwon.**, Kang, Youngho., **Lee, Joohan.**, **Chung, Changhyun.** and Lee, Han–Bo–Ram.
Applied Surface Science. 2025. 693.
doi: 10.1016/j.apsusc.2025.162749.

Ice accretion on surfaces presents significant challenges across various applications. To address this, hydrophobic polymer/ionic liquid (IL) composite coatings have emerged as effective solutions for enhancing anti–icing properties. In this study, we explored the potential of a poly(dimethylsiloxane) (PDMS)/IL/SiO₂ nanoparticle (NP) composite, employing two synergistic strategies: superhydrophobicity to reduce the ice/coating contact area and IL–induced quasi–liquid layer (QLL) formation to improve anti–icing performance. Density functional theory (DFT) calculations and structural analyses were performed to confirm IL dispersion within PDMS matrix, highlighting ion–dipole interactions between PDMS and 1–ethyl–3–methylimidazolium–bis(trifluoromethylsulfonyl) imide (EMIMTFSI). IL–integrated PDMS/SiO₂ composite exhibited a water contact angle (WCA) and water sliding angle (WSA) of 166.6 f 0.5 degrees and 4 f 1 degrees, respectively. The PDMS/IL/SiO₂ NPs composite coating exhibited an ice

adhesion strength (IAS) of 19 f 1 kPa, which is four times lower than that of the PDMS/SiO₂ NPs composite. Additionally, the IL–integrated superhydrophobic composite exhibited the FDT of 325 f 6 s, representing a 14–fold increase compared to that of a bare Al substrate. Overall, the IL–integrated coatings exhibited superior superhydrophobicity and QLL formation, leading to significantly improved FDT and a notable reduction in IAS. These sprayable IL–based composites show great promise as practical anti–icing coatings for extreme cold environments.

keywords:

Ionic liquid (IL); Density Functional Theory (DFT); Anti–icing; Quasi–liquid layer; Freezing Delay Time (FDT); Superhydrophobic Surface (SHS)

5-15 Engineering, Environmental; Engineering, Chemical

Tea waste-enhanced degradation of phenolic and pharmaceutical pollutants in the ferric ion/peroxymonosulfate system

Truong, Hanh Thi My., Tran, Khen Duy., Yu, Jonghun., **Ahn, Yong–Yoon.**, **Kim, Kitae.** and 2 others.
Journal of Environmental Chemical Engineering. 2025. 13(2).
doi: 10.1016/j.jece.2025.115336.

This study explores the practical potential of tea waste for degrading phenolic and pharmaceutical pollutants in water. The addition of tea waste to the Fenton–like system (i.e., the ferric ion/peroxymonosulfate (Fe^{III}/PMS) system) notably enhanced its efficiency in degrading 4–chlorophenol (4–CP), increasing from 7.1 % without tea waste to 100 % with tea waste after 2 h of reaction. Electron paramagnetic resonance spectroscopy, UV–visible spectroscopy, and liquid chromatography demonstrate that catechins extracted from tea waste play a crucial role in increasing degradation efficiency by reducing Fe^{III} to Fe^{II} through the formation of catechin–Fe^{III} complexes. This process facilitates the activation of PMS to radical species, such as sulfate (SO^{4•–}) and hydroxyl radicals (•OH). Among these two radical species, SO^{4•–} acts as the main oxidant for the degradation of 4–CP, as verified by radical quenching experiments. The optimal condition of the Fe^{III}/PMS/tea waste system was investigated by conducting experiments that varied the pH, PMS concentration, Fe^{III} concentration,

tea waste dosage, and the presence of water impurities. The Fe^{III}/PMS/tea waste system efficiently degraded all 11 tested phenolic and pharmaceutical pollutants. The strategy of utilizing tea waste as an accelerator in Fenton-like systems reduces not only the material cost for water treatment but also the disposal cost of tea waste.

keywords:
Tea waste utilization; Peroxymonosulfate activation; Catechins; Sulfate radical; Aqueous organic pollutant

5-16

The Development and Preliminary Operation Results of An Icequake Monitoring System

Moon, Jungho., Ko, Chihye. and Kim, Hyoung-Kwon.
Journal of IEEE. 2025. 29(1): 42-48.
doi: 10.7471/ieee.2025.29.1.42

Icequakes in glaciers serve as critical indicators for understanding glacial dynamics and predicting resultant environmental changes. This paper presents the development and preliminary operation results of an icequake monitoring system capable of real-time measurement, data storage, and wireless transmission to a remote server when connectivity is available. Unlike conventional seismic equipment, the proposed battery-powered system can reliably operate for over six months without operator intervention, even in remote glacial regions. Its performance was validated through domestic tests, confirming its ability to detect seismic events. Additionally, it was deployed near Jang Bogo Station at Browning Pass, Antarctica, where it demonstrated stable operation under extreme environmental conditions.

keywords:
Icequakes; Glaciers; Accelerometers; Monitoring; Antarctica

5-17

The Integrated System Development Direction for Expanding the Application of Polar Spatial Information

Lee, Bomi., Lee, Sungjae. and Kim, Hyun-Cheol.
The Geographical Journal of Korea. 2025. 59(3): 205-221.
doi: 10.22905/kaopgj.2025.59.3.4.

As global warming causes rising ocean temperatures, the decline of glaciers in the polar regions is accelerating. Because the Antarctic and Arctic are vast in scale and difficult to access, there were limitations in immediately detecting changes. However, as accessibility to the polar regions improves each year, data acquisition through exploration of the polar regions is becoming easier, accordingly, research to develop a new Arctic shipping route is emerging as a new national agenda. Since 2010, In Korea, Korea Polar Research Institute(KOPRI) has been conducting polar ocean research by obtaining various types of polar ocean observation data using the icebreaker research vessel “Araon”. This “Araon” operates during the summer season in polar regions(the Arctic : July to October, the Antarctic : November to March), but as the number of days of operation on the Northern Sea Route increases every year, it is considered a green light for developing the Northern Sea Route. With the advancement of IT and computing technology, spatial information has rapidly permeated every aspect of our lives. With the evolution of various spatial information platforms and the recent integration of technologies like IoT and AI, it is being widely utilized in diverse fields such as autonomous driving, smart cities, fire prevention, environmental protection, resource management, and climate change. Therefore, the purpose of this study is to suggest a direction for the construction of an integrated polar spatial information system to promote the utilization of polar data, which is currently operated according to the individual tasks of each ministry, and to manage it continuously. This study is significant in that it expands the openness of polar spatial information and activates data sharing and utilization by suggesting directions through analysis of existing polar systems(Star, Kaos).

keywords:
Satellite Remote Sensing Team for the Arctic & Antarctic Research; Korea Arctic Ocean-data System; Vessel Araon; The Northern Sea Route; Polar Spatial Information

Environmental Sciences; Remote Sensing; Imaging Science & Photographic Technology

Volatility Characteristics and Hyperspectral-Based Detection Models of Diesel in Soils

Shin, Jihye., Yu, Jaehyung., Seo, Jihee., Wang, Lei. and Kim, Hyun-Cheol.
Science of Remote Sensing. 2025. 11: 100201.
doi: 10.1016/j.srs.2025.100201.

This study developed an efficient method using hyperspectral camera for detecting diesel content in soils with spectral indices. Over 70 days of the experiment, clean soils were saturated with diesel, and 186 measurements were taken to monitor the evaporation rate and spectral variation. The diesel evaporation followed a logarithmic pattern, where the diesel volatility decreased from 1.57% per day during the initial period to 0.06% per day during the late period. Using the hull-quotient reflectance at 2236 nm, the diesel content prediction model derived from a stepwise multiple linear regression (SMLR) achieved satisfactory accuracy with sufficient statistical significance ($R^2 = 0.89$, RPD = 2.52). This spectral band was well visualized for diesel presence in hyperspectral images as the band infers variations in two absorptions (CH/AIOH and CH) concurrently. Additionally, this study presented an age estimation model based on the diesel evaporation rate using the same spectral band. Given the fact that this study is based on the largest number of samples with the longest observation period and models were developed excluding atmospheric absorption bands, the simple form of the spectral index makes it applicable to large-scale diesel pollution detection with hyperspectral scanners or narrow-band multispectral cameras in real-world cases.

keywords:
Hyperspectral image; Diesel pollution; Volatility; Spectral index; Environmental monitoring

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