Polar Winter Climate and Processes: Towards Filling Knowledge Gaps in the Understanding of the Coupled Climate System

Programme

23rd – 25th April 2025

British Antarctic Survey

Cambridge

Key information

Website – Event information

Online attendance – Zoom Link: https://bas-ac-uk.zoom.us/j/95999875404; meeting ID: 959 9987 5404

Subsistence

Lunch (inc. vegetarian options), teas, and coffees will be provided. The canteen is open for anything else as needed. This closes at 16:00 (sometimes earlier but please ask if you want something near closing time).

There will be a dinner at Christs College (https://www.christs.cam.ac.uk) on Thursday 24th April, time 19:00 (Drinks at 7pm, dinner served at 7.30)

Travel – If you need any help with booking travel, please get in touch with event organisers.

File access – Presentations can be uploaded here (SURFEIT Workshop April 2025)

Etherpad links:
PolarWinterClimate Theme 1 https://pad.riseup.net/p/PolarWinterClimate_Theme_1-keep
PolarWinterClimate Theme 2 https://pad.riseup.net/p/PolarWinterClimate_Theme_2-keep
PolarWinterClimate Theme 3 https://pad.riseup.net/p/PolarWinterClimate_Theme_3-keep
PolarWinterClimate Theme 4 https://pad.riseup.net/p/PolarWinterClimate_Theme_4-keep

Programme

Wednesday 23rd April 2025

11:00	**Registration and refreshments**	
12:00	**Lunch**	
Welcome and Introductions		
13:00	Xin Yang and Markus Frey	
Theme 1: Polar winter storms, sea ice and climate impacts		Chairs: Alex Weiss, Melanie Fuelster
13:05	Ola Persson	KEYNOTE: Air-ice-ocean coupling during cyclone events in the central Arctic
13:30	Xiangdong Zhang (online)	Climatology, Variability, and Changes of Arctic Cyclones and Impacts on Arctic Sea Ice and Ocean
13:40	Wen Zhou (online)	A frequent ice-free Arctic is likely to occur before the 2050s
13:50	Zili Shen	Quantifying the relative contribution of internal variability and external forcing on Arctic sea ice variations
14:00	**Comfort break**	
14:10	Sergi González-Herrero	Physical insights on winter heatwave intensification of the March 2022 event in Antarctica using Pseudo-global warming simulations
14:20	Yuqing Wang	Global warming has significantly shifted the occurrence of heatwave events into the Antarctic interior
14:30	Alexandra Stephens (online)	The Characterization and Impact of Extreme Winds in Nares Strait
14:40	Feiyue Wang (online)	Introducing the Churchill Marine Observatory: A new outdoor mesocosm facility for process-oriented studies across the ocean-sea ice-atmosphere interface
14:50	Poster session – Lightning presentations	Eugenia Garbarini (online); Raven Quilestino-Olario; Yuzhuo Peng; Lise Dekoster; Zheng-Hang Fu; Qigang Wu (online), Patrick Martineau/Hua Lu; Satyajit Singh Saini (online)
15:30	**Coffee break**	
16:00	Poster session continues	
17:30	**Close**	

Thursday 24th April 2025

Theme 2: Polar winter aerosol, clouds and chemistry		Chairs: Xianda Gong & Xin Yang
9:05	Martin Radenz (online)	KEYNOTE: Advancing observations of aerosol-cloud interaction during polar winter with remote sensing
9:30	Mark Tarn	Ice-nucleating particle measurements during the Southern Ocean Clouds research cruise
9:40	Markus Frey	Should clouds care about aerosol from blowing snow above sea ice during Arctic winter/spring?
9:50	Xinyi Huang	Different responses of cold-air outbreak clouds to aerosol and ice production depending on cloud temperature
10:00	Imogen Wadlow	Parameters determining the representation of Arctic cloud-forming aerosols in UKESM
10:10	**Coffee break and PHOTO**	
10:40	Xianda Gong	Local Blowing Snow Surpassing Long-range Transported Pollution on Aerosol Loading and Surface Warming in the Arctic
10:50	Dominik Heger (online)	Parameters governing the size and density of sea salt aerosols formed from the sublimating saline crystals: temperature, salt concentration, and freezing rates
11:00	Guang Li	A drifting and blowing snow model considering saltating fragmentation
11:10	Joël Savarino (online)	Nocturnal polar snow chemistry hiatus at Concordia station
11:20	Radim Štůsek	Freezing-induced acidification of sea ice brine
11:30	Ross Herbert	Low-latitude dust emitted in summer months may impact polar winter INP availability
11:40	Poster session and BAS building tour	
12:30	**Lunch break**	
Theme 3: Polar-mid-latitude and polar-lower-latitude teleconnections		Chairs: Sergi Gonzalez-Herrero, Ksenija Vučković
13:35	Irina Gorodetskaya	KEYNOTE: Atmospheric Rivers in Antarctica and lower-latitude teleconnections: Insights from the Winter YOPP-SH Targeted Observations

14:00	Varunesh Chandra	Dynamics of High-Latitude Atmospheric Blocking and Teleconnection to North American Winter Extremes: A viewpoint from potential vorticity gradient
14:10	Hao Wang	Dynamical hints for the seasonality of Amundsen Sea Low
14:20	Magdalena Muir (online)	Changes and Trends for Atmospheric Rivers for Arctic and Mid Latitudes of Western North America
14:30	Divya Sardana (online)	Spring Sea Ice Variability in the Barents-Kara Region and its impact on the Indian Summer Monsoon Rainfall
14:40	Xin Wang	The Synergistic Impact of the Autumn Barents-Kara Sea and Baffin Bay-Hudson Bay Sea Ice Dipole on South China Spring Precipitation
14:50	Melanie Fuelster	Large-scale atmospheric processes leading to fast ice breakout events in McMurdo Sound in winter 2022
15:00	**Coffee break**	
15:30	Breakout discussions on Theme 1, 2 & 3 (sub-groups mixed with in-person and online participants): focusing on **urgent research priorities in each Theme** Etherpad links: Theme 1 https://pad.riseup.net/p/PolarWinterClimate_Theme_1-keep Theme 2 https://pad.riseup.net/p/PolarWinterClimate_Theme_2-keep Theme 3 https://pad.riseup.net/p/PolarWinterClimate_Theme_3-keep Group 1 (conference 1) chairs: Alex Weise, Melanie Fuelster; Rapporteurs: Raven Quilestino-Olario and Guang Li Group 2 (seminar room 1) chairs: Xin Yang and Xianda Gong; Rapporteurs: Ksenija Vučković; Radim Štůsek and Imogen Wadlow Group 3 (seminar room 2) chairs: Sergi Gonzalez-Herrero, Ksenija Vučković; Rapporteurs: Varunesh Chandra, Hao Wang	
17:10	Report back to all	
17:30	**Close**	
19:30	**Dinner at Christs College**	

Friday 25th April 2025

Theme 4: Knowledge gaps to fill	Chair: Markus Frey, Rainette Engbers

9:15	Tom Bracegirdle	KEYNOTE: Antarctic weather and climate extremes in a warming world, recent research progress and future priorities
9:40	Zhaohui Wang	Coupled Influence of Synoptic Weather and Topographic Control on Near-surface Wind Variability in the Denman Glacier Basin, East Antarctica
9:50	Heather Corden (online)	AWACA: Instrument Deployment and Case Studies of Snowfall with Meteorological Radars
10:00	Ksenija Vučković	Microbial Biodiversity of Precipitation in the Northern Antarctic Peninsula: Observations during Summer and Implications for Winter
10:10	Peter Convey	Storm-driven 'rain-on-snow' events in the polar winter have important consequences in terrestrial ecosystems
10:20	Amit Singh Chandel (online)	Unveiling the Hidden Culprit: How Dust Storms Accelerate Himalayan Glacier Melt
10:30	**Coffee break**	
11:00	Discussions on Theme 4: focusing on **5 urgent knowledge gaps to fill**, using Etherpad link: Theme 4 https://pad.riseup.net/p/PolarWinterClimate_Theme_4-keep Session chairs: Markus Frey, Rainette Engbers; Rapporteurs: Raven Quilestino-Olario and Zhaohui Wang (potential to break up groups)	
12:00	Report back to all	
12:25	Wrap-up: Xin Yang and Xiangdong Zhang	
12:30	**Lunch**	
13:00	**Close of the meeting**	

List of Attendees

Name	Organisation	Attendance
Abigail Waring	University of Leicester/NCEO UK	Online
Aleksandra Elias Chereque	University of Toronto, Canada	Online
Alexandra Stephens	University of Toronto, Canada	Online
Alexandra Iris Weiss	British Antarctic survey	In person
Alicia Fallows	University College London (UCL), UK	Online
Amit Singh Chandel	IIT MADRAS, India	Online
Andrew Pauling	University of Otago, New Zealand	Online
Audrey Huff	University of Alaska Anchorage - Alaska Center for Conservation Science, USA	Online
Boris Barja	Universidad de Magallanes	Online
Carley Iles	CICERO Center for International Climate Research, Norway	Online
Daniel Smith	University of East Anglia	Online
David Winker	NASA, USA	Online
David Mikolajczyk	Antarctic Meteorological Research and Data Center, Space Science and Engineering Center, UW-Madison, USA	Online
Delia Segato	Joint Research Centre, European Commission	Online
Devendra Pal	McGill University, Canada	Online
Divya Sardana	Indian Institute of Technology Roorkee, Roorkee, India	Online
Dominik Heger	Masaryk University, Czech Republic	Online
Ella Gilbert	British Antarctic Survey	In person
Eugenia Garbarini	Servicio Meteorologico Nacional Argentina	Online
Evangeline Rowe	University of Cambridge	In person
Feiyue Wang	University of Manitoba, Canada	Online
Floortje Van den Heuvel	British Antarctic Survey	In person
Freya Squires	British Antarctic Survey	In person
Gaelle Veyssiere	British Antarctic Survey	In person
Genevieve Beauregard	University of Cambridge	In person
Gillian Cheong	Brown University, USA	Online
Gosha Geogdzhayev	University of Cambridge	In person
Guang Li	Lanzhou University, China	In person
Hao Wang	Department of Atmospheric and Oceanic Sciences, Fudan University, Shanghai, China	In person
Heather Corden	École Polytechnique Fédérale de Lausanne (EPFL), Switzerland	Online
Imogen Wadlow	Institute for Climate & Atmospheric Science, School of Earth & Environment, University of Leeds & National Centre for Atmospheric Science, UK	In person
Insha Batool	National University of Sciences and Technology (NUST), Islamabad Pakistan	Online
Irina Gorodetskaya	CIIMAR - Interdisciplinary Centre of Marine and Environmental Research of the University of Porto	In person
Joana Baptista	Instituto de Geografia e Ordenamento do Território da Universidade de Lisboa, Portugal	Online
Joel Savarino	IGE/CNRS, France	Online
Joo-Hong Kim	Korea Polar Research Institute, Republic of Korea	Online

Kaushal Kumar	HNBGU, India	Online
Kimberly Strong	University of Toronto, Canada	Online
Ksenija Vučković	CIIMAR - Interdisciplinary Centre of Marine and Environmental Research of University of Porto, Portugal	In person
Lena Bruder	Institute for Geophysics and Meteorology, Cologne	Online
Lisa Miller	Institute of Ocean Sciences/Fisheries and Oceans Canada	Online
Lise Dekoster	University of Liège, Belgium	In person
Louise Sime	British Antarctic Survey	In person
Lu Zhang	Aarhus University, Denmark	Online
Ľubica Vetráková	Institute of Scientific Instruments of the Czech Academy od Science, Czechia	Online
Magdalena Muir	Arctic Institute of North America and Bamfield Marine Sciences Centre	Online
Manuel Dall'Osto	Institut de Ciències del Mar, the Spanish National Research Council, Spain	Online
Marcel du Plessis	University of Gothenburg, Sweden	Online
Marianne Lund	CICERO Center for International Climate Research	Online
Mark Tarn	University of Leeds, UK	In person
Markus Frey	British Antarctic Survey	In person
Martin Radenz	TROPOS, Germany	Online
Mary Stack	University of Virginia, USA	Online
Masakazu Yoshimori	Atmosphere and Ocean Research Institute, The University of Tokyo	Online
Megan Malpas	British Antarctic Survey	In person
Melanie Fuelster	SLF Switzerland	In person
Michael Wethington	Biodiversity Research Institute	Online
Michael Matějka	Masaryk University, the Czech Republic	Online
Michael Herzog	University of Cambridge	In person
Mittu Walia	Indian Institute of Technology Roorkee	In person
Mohan Murali Krishna Gorja	National Institute of Technology Rourkela, India	Online
Monojit Saha	University of Maryland & US	Online
Neil Brubacher	University of Victoria, Canada	Online
Nina Kinney	British Antarctic Survey	In person
Ninu Krishnan Modon Valappil	Universiti Sains Malaysia, Malaysia	Online
Ola Persson	University of Colorado, Boulder, Colorado USA	In person
Olimpia Bruno	Karlsruhe Institute of Technology	Online
Patrick Martineau	Japan Agency for Marine-Earth Science and Technology, Yokohama, Japan	Online
Peter Convey	British Antarctic Survey	In person
Peter Wadhams	University of Cambridge	Online
Phoebe Jackson	Scott Polar Research Institute, UK	In person
Polina Sevastyanova	University of Cambridge / British Antarctic Survey	In person
Qigang Wu	Department of Atmospheric and Oceanic Sciences, Fudan University, Shanghai, China	Online
Radim Štůsek	Masaryk University, Czechia	In person
Rainette Engbers	CRYOS - Ecole Polytechnique Fédérale de Lausanne (EPFL)	In person
Rajendran Shobha Ajin	University of Florence, Italy	Online

Raven Quilestino-Olario	Institut für Geologie und Mineralogie, Universität zu Köln / Germany	In person
Romy Hall	British Antarctic Survey	In person
Ross Herbert	ICAS, University of Leeds, UK	In person
Ryan Williams	British Antarctic Survey	In person
Sarah Woods	NSF NCAR, USA	Online
Satyajit Singh Saini	Indian Institute of Technology Roorkee, India	Online
Sergi González Herrero	SLF, Switzerland	In person
Sihan Li	The University of Sheffield, UK	Online
Sofia Guest	Queen's University, Canada	Online
Steve Colwell	British Antarctic Survey	In person
Steven Abel	Met Office, UK	Online
Thomas Caton Harrisson	British Antarctic Survey	In person
Tom Bracegirdle	British Antarctic Survey	In person
Tracy Moffat-Griffin	British Antarctic Survey	In person
Varunesh Chandra	University of Washington, US	In person
Vera Schemann	University of Cologne, Germany	Online
Wael Kouki	University of Chicago, USA	Online
Wen Zhou	Fudan University, China	Online
Xianda Gong	Westlake University, China	In person
Xiangdong Zhang	North Carolina State University, USA	Online
Xin Yang	British Antarctic Survey	In person
Xin Wang	Fudan University, Shanghai, China	In person
Xinyi Huang	University of Leeds, United Kingdom	In person
Yan Xie	University of Michigan, United States	Online
Yonghan Choi	Korea Polar Research Institute, South Korea	Online
Yuqing Wang	Fudan University, China	In person
Yuzhuo Peng	Xiamen University, China	In person
Zhaohui Wang	University of New South Wales, Australia	In person
Zheng-Hang Fu	Fudan University, China	In person
Zili Shen	Fudan University, China	In person
Zosia Staniaszek	CICERO, Norway	Online

Abstracts

Alexandra Stephens: The Characterization and Impact of Extreme Winds in Nares Strait

(Alexandra Stephens, University of Toronto

G. W. Kent Moore, University of Toronto)

Extreme winds in the Arctic can affect sea ice flow, the formation of open-water areas called polynyas, ocean convection, and maritime and aviation activity. This work investigates a severe wind event that demolished a research ice camp in Nares Strait in April 2005. We aim to determine whether the event was extreme or typical for the region and quantify its exceptionality. Nares Strait is a long, narrow body of water between Ellesmere Island (Nunavut, Canada) and northwestern Greenland. There are steep mountains on both sides, significantly impacting meteorological phenomena and making it difficult to accurately model weather events in the area. Therefore, we used the new Copernicus Arctic Regional Re-analysis (CARRA) data with 2.5 km horizontal resolution, covering the period 1991-2022, to characterize the wind climate of the region. Our results indicate that the winds were extreme at specific points in space and time during the April 2005 storm, briefly exceeding the 95th percentile, although most winds did not exceed this mark. The re-analysis generally concurs with the oceanography camp's description of events, although some of the highest observed wind speeds were not captured in the dataset. This result has implications for future research expeditions and the Arctic Climate System since the wind in Nares Strait controls the flow of most old, thick sea ice that exits the Arctic.

Amit Singh Chandel: Unveiling the Hidden Culprit: How Dust Storms Accelerate Himalayan Glacier Melt

(Amit Singh Chandel, Indian Institute of Technology Madras, Civil Engineering, Chennai, India

Chandan Sarangi, Indian Institute of Technology Madras, Civil Engineering, Chennai, India

Karl Rittger, Institute of Arctic and Alpine Research, University of Colorado, Boulder

Rakesh K. Hooda, Finnish Meteorological Institute, Helsinki, Finland

Antti-Pekka HYVARINEN, Finnish Meteorological Institute, Helsinki, Finland)

While global warming has long been considered the primary driver of glacier retreat, this groundbreaking study reveals a lesser-known yet significant contributor to the accelerated melting of Himalayan glaciers: pre-monsoonal dust events. Our research challenges the conventional wisdom by demonstrating how these dust storms dramatically alter snow surface albedo, potentially rivaling the impact of rising temperatures on glacier melt rates. Using a combination of satellite observations and in-situ measurements from the high-altitude site of Mukteshwar, we identified and analyzed ten major dust events in the Indian Himalayas. These events were categorized into two distinct types: Mineral Dust Events (MDEs) and Polluted Dust Events (PDEs), each with unique characteristics and impacts.

Our findings reveal a startling increase in aerosol loading during these events, with coarse particle concentrations skyrocketing by 400% and extinction coefficients surging by 175% compared to background

conditions. More critically, we uncovered a significant difference in how MDEs and PDEs affect snow albedo reduction (SAR). PDEs, enriched with black carbon and anthropogenic pollutants, nearly doubled the SAR compared to normal conditions, while MDEs also increased SAR, albeit to a lesser extent. This research paints a more complex picture of the forces driving glacier melt in the Himalayas. It highlights how dust storms, particularly those carrying pollutants from nearby regions, can significantly amplify the melting process by darkening snow surfaces and increasing solar radiation absorption. These findings underscore the urgent need to consider dust events alongside global warming in climate models and conservation strategies. By shedding light on this often-overlooked factor, our study opens new avenues for understanding and mitigating the rapid loss of Himalayan glaciers. It calls for a paradigm shift in how we approach glacier conservation, emphasizing the need for comprehensive strategies that address global warming and regional dust pollution to safeguard these critical water towers of Asia.

Divya Sardana: Spring Sea Ice Variability in the Barents-Kara Region and its impact on the Indian Summer Monsoon Rainfall

(Divya Sardana, Department of Hydrology, Indian Institute of Technology, Roorkee, Uttarakhand, India

Ankit Agarwal, Department of Hydrology, Indian Institute of Technology, Roorkee, Uttarakhand, India)

The rapidly changing Arctic climate plays a pivotal role in shaping global weather patterns, primarily through high-latitude teleconnections. While Arctic-midlatitude interactions are well studied, the influence of Arctic variability on tropical systems, particularly the Indian Summer Monsoon Rainfall (ISMR), remains relatively unexplored. This study assesses how spring (March-May) sea ice anomalies in the Barents-Kara (B-K) region influence ISMR variability from 1959 to 2021. By classifying years into low- and high-sea-ice phases, we identify distinct atmospheric circulation patterns that drive monsoonal variations over India. During low-sea-ice years, diminished ice cover over the B-K region results in negative summer sea level pressure anomalies, fostering cyclonic activity and triggering a southward-propagating Rossby wave train. This wave train establishes a ridge-trough-ridge-trough structure extending from Europe to the Far East and the North Pacific, shifting the subtropical westerly jet southward. The resulting subsidence suppresses convection over the Indo-Gangetic Plain, weakening monsoon rainfall. Conversely, high-sea-ice years exhibit an opposite circulation pattern, characterized by negative geopotential height anomalies over the B-K region and a ridge over Central Asia. This pattern enhances upper-level divergence, strengthens convective activity, and reinforces monsoonal rainfall over India. Our findings highlight the crucial role of springtime B-K sea ice in modulating summer atmospheric circulation and ISMR, underscoring the broader impact of Arctic sea ice variability on tropical climate systems.

Dominik Heger: Parameters governing the size and density of sea salt aerosols formed from the sublimating saline crystals: temperature, salt concentration, and freezing rates

(Dominik Heger, Masaryk University, Brno, Czech Republic

Lukáš Veselý, Masaryk University, Brno, Czech Republic

Radim Štůsek, Masaryk University, Brno, Czech Republic

Xin Yang, British Antarctic Survey, Natural Environment Research Council, Cambridge, UK

Kamila Závacká, Environmental Electron Microscopy Group, ISI Czech Academy of Sciences, Brno, Czech Republic

Vilém Neděla, Environmental Electron Microscopy Group, ISI Czech Academy of Sciences, Brno, Czech Republic

Martin Olbert, Environmental Electron Microscopy Group, ISI Czech Academy of Sciences, Brno, Czech Republic

Eva Tihlaříková, Environmental Electron Microscopy Group, ISI Czech Academy of Sciences, Brno, Czech Republic

Ľubica Vetráková, Environmental Electron Microscopy Group, ISI Czech Academy of Sciences, Brno, Czech Republic)

Chemical reactions in the Arctic region primarily occur within the ice matrix or on the surface of sea-salt aerosols (SSAs). However, the substrates for heterogeneous reactions, particularly the release of reactive bromine, remain uncertain and are the subject of debate in the literature. We report on the microstructural changes accompanying freezing, cooling, and sublimation of seawater across a range of saline concentrations from 70 to 0.35 psu, examined using an environmental scanning electron microscope. It is demonstrated that low salinity and temperature conditions are conducive to the substantial production of small, aerosolized particles during sea ice sublimation. Specifically, it is observed that at temperatures below -20 °C, micron-sized pieces of salt form, while at higher temperatures, larger chunks of salt appear. With regard to saline concentration, micron-sized particles are exclusively observed at salinities below 3.5 psu, and at salinities under 0.085 psu, SSA particles with a median size smaller than 6 micrometers arise from sea ice at any sub-zero temperature. Consequently, the present laboratory study provides a microscopic explanation for the seemingly paradoxical observations concerning the production of large amounts of aerosolised SSAs at low temperatures and low salinity, and the negligible likelihood of such production at higher salt concentrations (e.g. found on frost flowers).

Eugenia Garbarini: Analysis of Extreme Maximum Temperature Variability in Northeastern Antarctic Peninsula (POSTER)

(Eugenia Garbarini, Servicio Meteorológico Nacional, Argentina

María de los Milagros Skansi, Servicio Meteorológico Nacional, Argentina.

Benitez Gerardo Carbajal, Servicio Meteorológico Nacional, Argentina)

Several studies have documented significant changes in Antarctic temperatures, particularly in the Peninsula region. Among Argentina's Antarctic bases, Marambio stands out as a year-round research station, playing a crucial role in atmospheric and climate studies due to its strategic location and high level of human activity. This work aims to assess the behaviour of daily maximum air temperature (Tmax) from 1986 to 2024, with a focus on variability and extreme temperature events. To achieve this, we calculated the percentage of days per year with Tmax above the 95th percentile, using the Tmax distribution from 1991-2020 and a 5-day rolling window. Results reveal a significant increase in the number of extreme Tmax days over time, with 95% level of confidence using a Mann-Kendall test. Furthermore, heatwave events were identified as those in which Tmax exceeded the 95th percentile for three or more consecutive days. These events have shown to be more likely to start in December, followed by May, July, and April, highlighting the need to further explore autumn and winter behaviours. Notably, the years 1998 and 2016 recorded the highest number of heatwave events, both occurring primarily in autumn and winter. Since 2016, a shift in patterns has been observed, with extreme events becoming longer and occurring more frequently in summer and autumn. Future analysis will deepen this analysis

and explore how atmospheric composition, particularly ozone concentration, and circulation patterns influence the variability of maximum temperatures in Marambio.

Feiyue Wang: Introducing the Churchill Marine Observatory: A new outdoor mesocosm facility for process-oriented studies across the ocean-sea ice-atmosphere interface

(Feiyue Wang, University of Manitoba, Winnipeg, Canada)

Mesocosm-scale sea ice research in Canada started in 2012 with the opening of the Sea-ice Environmental Research Facility (SERF) at the University of Manitoba in Winnipeg. Building upon the success of SERF, a new major research facility, the Churchill Marine Observatory (CMO), was officially opened in August 2024 in Churchill on the southwest coast of Hudson Bay. At the core of the CMO is an outdoor Ocean-Sea-Ice-Mesocosm (OSIM) with two large pools that are designed to support mesocosm-scale, process-oriented studies across the ocean-sea ice-atmosphere interface in polar regions. The two pools are of identical dimensions to accommodate experimental studies with a control system. The facility is also equipped with on-site laboratories and an atmospheric station for real-time meteorology and atmospheric chemistry. In this presentation I will introduce the capacity of the CMO, showcase a few studies carried out over its inaugural season, and invite discussions on how such a mesocosm approach might be useful in addressing some of the critical knowledge gaps in our understanding of the polar climate system.

Guang Li: A drifting and blowing snow model considering saltating fragmentation

(Guang Li, Lanzhou University, China)

Drifting and blowing snow shape snow patterns over snow-covered areas and impact atmospheric physical and chemical processes via sublimation of airborne snow particles. However, current models usually use a time-independent particle size distribution when describing the drifting and blowing snow processes, ignoring the change of particle size distribution due to sublimation and saltating particle fragmentation. This work introduces a fragmentation model into a well-developed drifting and blowing snow model, to investigate how fragmentation affects the drifting and blowing snow processes. Compared with no fragmentation case, the model results show that fragmentation can greatly change the airborne particle size distribution and enhance the blowing sublimation. The model results of airborne particle size distribution along the height also show good agreement with previous experimental data. Our work helps a deeper understanding of the wind-blown snow process and contributes to a better description of winter climate.

Hao Wang: Dynamical hints for the seasonality of Amundsen Sea Low

(Hao Wang, Wen Zhou, Department of Atmospheric and Oceanic Sciences & Institute of Atmospheric Sciences, Fudan University, Shanghai, China)

The Amundsen Sea Low (ASL) is a principal climatological system of the Antarctic circulation. The intensity and location of the low vary a lot with seasons. Previous studies have shown that internal variability of the tropical sea surface temperature (SST), such as El Niño–Southern Oscillation and Atlantic SST variability, modulates the intensity and location of the ASL, with the greatest teleconnection found in austral winter. However, the climatological ASL is found strongest in austral spring. This study investigates the mechanisms behind the seasonality of ASL intensity using a Rossby wave ray tracing theory and experiments with a linear baroclinic model (LBM) forced with idealized diabatic heating. The results turn out that the seasonality of ASL intensity originate from the interaction between diabatic heating over the Maritime Continent, and background condition modulating the Rossby wave transport. During austral spring, precipitation over the Maritime Continent is strongest due to the migration of Intertropical Convergence Zone, and the local northerly favors the southward propagation of Rossby wave induced by reinforced diabatic heating. Thus, ASL is enhanced in this season. In austral winter, the northerly over the Maritime Continent still favors the southward propagation of Rossby wave, but the strong absolute vorticity near 30°S associated with the subtropical jet reflects the most Rossby waves from Maritime Continent. And in austral summer and autumn, the Maritime Continent is covered by the northerly flow, making it difficult for Rossby wave to travel southward. The results of Rossby wave activity explain and improve the understanding of the seasonality of ASL intensity.

Heather Corden: AWACA: Instrument Deployment and Case Studies of Snowfall with Meteorological Radars

(Heather Corden, Environmental Remote Sensing Laboratory, École Polytechnique Fédérale de Lausanne, EPFL, Lausanne, Switzerland

Alexis Berne, Environmental Remote Sensing Laboratory, École Polytechnique Fédérale de Lausanne, EPFL, Lausanne, Switzerland

Alejandro Salamanca, Environmental Remote Sensing Laboratory, École Polytechnique Fédérale de Lausanne, EPFL, Lausanne, Switzerland

Felipe Toledo Bittner, LATMOS, CNRS, Université Paris-Saclay, Paris, France

Christophe Caudoux, Laboratoire de Météorologie Dynamique, LMD/CNRS, Paris, France;

Vincent Mariage, Laboratoire de Météorologie Dynamique, LMD/CNRS, Paris, France

Christophe Le Gac, Laboratoire des Sciences du Climat et de l'Environnement, LSCE/IPSL, CEA-CNRS-UVSQ, Université Paris-Saclay, Gif-sur-Yvette, France

Olivier Jossoud, LATMOS, CNRS, Université Paris-Saclay, Paris, France

Thomas Lauwers, LATMOS, CNRS, Université Paris-Saclay, Paris, France;

Michael Monnet, Environmental Remote Sensing Laboratory, École Polytechnique Fédérale de Lausanne, EPFL, Lausanne, Switzerland

Valentin Simeonov, Environmental Remote Sensing Laboratory, École Polytechnique Fédérale de Lausanne, EPFL, Lausanne, Switzerland

Nicolas Pernin, French Polar Institute Paul-Émile Victor, IPEV, Brest, France

Elise Fourre, LATMOS,CNRS-UVSQ, Université Paris-Saclay, Paris, France,

Christophe Genthon, Laboratoire de Météorologie Dynamique, LMD/CNRS, Paris, France)

The ERC Synergy funded project AWACA aims to understand the atmospheric branch of the water cycle over Antarctica. It relies on innovative observations of the tropospheric meteorological conditions and the isotopic composition of water vapor and hydrometeors along a 1100 km transect between Dumont d'Urville station (DDU) at the coast and Concordia station on the high inner Antarctic plateau. The deployment of instruments was completed in the austral summer season from November 2024 to February 2025. The instruments will remain in place for three years. At DDU, a new solid state X-band (9.4 GHz) polarimetric scanning radar (StXPol) was deployed alongside an RPG 94 GHz cloud radar, a Metek MRR-PRO 24 GHz rain radar and a Multi-Angle Snowflake Camera (MASC). At four locations along the transect, temporary container-stations were deployed. Each container includes a Metek MIRA 35 GHz cloud radar, an MRR-PRO, a BASTA 95 GHz cloud radar, a microlidar and an Optical Feedback Cavity Enhanced Absorption Spectroscopy (OF-CEAS) water isotope instrument. Adjacent to each container is a comprehensive surface weather station.

This contribution will discuss the deployment of the instruments in the recent field season and their remote monitoring via satellite internet. Case studies from the deployment period will be presented and discussed in the context of changes in precipitation properties from the coast to the high plateau, focusing on the radar data. The multi-frequency dataset combined with the co-located weather station allows for investigation of precipitation macro- and micro-physics, including Doppler spectra and polarimetric analysis. Ongoing data treatment and first precipitation statistics will be discussed. Although the first winter data will not yet be available, the continuous observations have high potential for improving winter processes understanding in the coming years.

Igor Appel (Cancelled): Knowledge Gaps in Studying Seasonal Terrestrial Snow Cover

(Igor Appel, TAG LLC)

Traditionally terrestrial snow cover gets less attention than other cryosphere components and presents a gap in cryosphere monitoring and therefore in support of the scientific understanding of the physical climate basis.

Snow accumulation plays a critical role in various processes during polar winter modifying, first of all, energy and mass exchange between the atmosphere and underlying surfaces. Not accurate simulation of snow cover evolution to a large degree explains noticeable shortcomings in representing polar weather and climate by current models, especially during winter. The accuracy of simulating snow distribution by large scale models are usually even not estimated quantitatively.

If climate models do not reproduce current seasonal and interannual changes in redistribution of terrestrial snow cover than their capabilities to estimate future conditions remain doubtful not only in the Arctic and Antarctica but for the climate system on the whole. Thus, identifying existing knowledge gaps in Studying Seasonal Terrestrial Snow Cover is critically important to our understanding of the overall climate system.

The snow cover maps derived from satellite observations present the best possible source of information relevant to numerous applications used to measure, model, and manage water resources. The information on snow is also necessary to many land downstream products retrieved from remote sensing and models.

According to surveys of users, snow cover area (SCA) and fractional snow cover (FSC) are considered as the most important snow cover characteristics. However, the applicability of the algorithms for global or even pan European snow mapping has not been convincingly demonstrated. Moreover, FSC was explicitly identified as a significant gap in snow remote sensing.

The estimation of fractional snow cover is a high priority task due to user requirements and because this property of the snow cover is critical for retrieval of many atmosphere and land products. Therefore, comparison of various algorithms is mandatory to create terrestrial snow cover monitoring.

The development of enhanced information on snow cover: snow fraction and physical properties requires significant efforts because of the influence of numerous factors on snow characteristics and their retrieval. The quality of snow products is determined by finding relevant endmembers changing from one scene to another as well as in the same location depending on geometry of observation and surface state.

Snow products could be improved if the variability of properties characterizing snow and underlying non-snow is taken into consideration. Allowing for the variability in endmembers (spectral signatures or Normalized Difference snow Index, NDSI) is a key requirement to adjust snow algorithms to specific local conditions making the algorithms applicable to global retrieval.

The question of snow data quality also needs additional consideration. Existing problems in estimate of snow products are to a large degree caused by the absence of a common general approach to prepare reference data.

Analysis and validation of snow retrieval is typically made on the basis of joint using of snow measurements at different resolutions: medium with high-resolution or high with very high resolution.

Collaboration between researchers with experiences supplementing each other can be a very promising way to tackle the problem of optimizing information on Terrestrial Snow Cover. Such collaboration including the private sector of very high resolution data providers should be considered as a key recommendation to achieve improvements in terrestrial snow products.

Transparency of the methodologies applied to retrieve and estimate snow products is important for improved developments of terrestrial snow cover monitoring. However, some groups off scientists do not share their developments not only during studies, but for several years after end of projects.

Imogen Wadlow: Parameters determining the representation of Arctic cloud-forming aerosols in UKESM

(Ken Carslaw, Institute for Climate & Atmospheric Science, University of Leeds, UK

Ryan Neely, National Centre for Atmospheric Science, UK)

Enhancing the representation of aerosols in Global Climate Models (GCMs) is essential for reducing uncertainties associated with aerosol-cloud interactions. This study identifies and examines the dominant parameters that control cloud-forming aerosols over the Arctic region within the United Kingdom Earth System Model (UKESM), coupled with UKCA (United Kingdom Chemistry and Aerosols) and the aerosol microphysical scheme GLOMAP (Global Model of Aerosol Processes). The role of 37 aerosol-cloud-relevant parameters in determining accumulation-mode number and size were examined using a Perturbed Parameter Ensemble, which simulated 220 unique parameter combinations within observationally-plausible ranges. Key parameters were identified spatially across the Arctic which had the most important effect on determining the representation of accumulation-mode aerosols, indicating areas for further model development in constraining physical processes, and natural/anthropogenic emissions. Additionally, a consistent seasonal bias was identified in simulated aerosol size, suggesting a structural error within UKESM-UKCA-GLOMAP.

Irina Gorodetskaya (KEYNOTE): Atmospheric Rivers in Antarctica and lower-latitude teleconnections: Insights from the Winter YOPP-SH Targeted Observations

(Irina Gorodetskaya, CIIMAR - Interdisciplinary Centre of Marine and Environmental Research, University of Porto, Portugal

The YOPP-SH Winter Task Team)

Antarctica is losing ice at an accelerated pace with ice mass losses being dominated by West Antarctic ice sheet (WAIS) and the Antarctic Peninsula (AP) (Otosaka et al. 2022). The near-surface temperature in WAIS and the AP has been increasing at a rate twice the global average during the past 30 years. This warming amplification has been related on the one hand to increasingly positive Southern Annular Mode and stronger circumpolar westerlies associated with increased greenhouse gas forcing and reduced stratospheric ozone. On the other hand, strong tropical-polar interconnections have been put forward as another key factor in WAIS and AP warming (Li et al. 2021). Particularly in winter, wide spread WAIS warming has been linked to tropical Pacific sea surface temperature increase generating stationary atmospheric Rossby wave response, which in turn influence the Amundsen Sea Low and warm air intrusions into Antarctica (Ding et al. 2021). Coupling with a strong blocking helps to direct anomalous moisture and heat poleward advection along narrow corridors known as atmospheric rivers (ARs) towards Antarctica – known to bring anomalously high temperatures, widespread surface melt and rainfall to the AP and WAIS both in summer and winter (Gorodetskaya et al. 2023; Evangelista et al. 2023; Bozkurt et al. 2024; Gilbert et al. 2025; Wille et al. 2025). Despite their important impacts, winter warm events have been significantly understudied – to a large extent due to much more limited observations during winter season in Antarctica. With a goal of improving our understanding and representation in models of Antarctic winter climate, the Year of Polar Prediction in the Southern Hemisphere (YOPP-SH) - an international initiative guided by the WMO's World Weather Research Programme – conducted a special enhanced observational period during winter 2022 with unprecedented international collaboration combining efforts of more than 15 countries (Bromwich et al. 2024). The winter YOPP-SH included seven targeted observing periods (TOPs) of 5-10 days long, most of which were associated with ARs. This presentation will discuss preliminary results from the winter YOPP-SH TOPs combined with enhanced ground-based observations at selected stations. The importance of regional and local impacts such as snowfall to rainfall transitions will be demonstrated using radar precipitation measurements available during YOPP-SH and beyond. Representing a range of scales – from large-scale teleconnections to mesoscale dynamics and important regional and local scale impacts – ARs in Antarctica and their relationship to lower latitude rapid changes require comprehensive sustained efforts towards all-season and long-term observations together with improved representation in climate models.

Joel Savarino: Nocturnal polar snow chemistry hiatus at Concordia station

(Joël Savarino, IGE/CNRS, Grenoble, France

Albane Barbero, IGE/CNRS, Grenoble, France

Katya Tkachenko, Institute of Geological Science (IGS), National Academy of Science of Ukraine, 01054, Gonchara Str 55b, Kyiv, Ukraine

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and Concordia and internship support, IGE/CNRS, Grenoble, France)

It is well established that snow cover exposed to UV solar radiation produces nitrogen oxides through the photodissociation of the nitrate contained in the snow. It is therefore generally accepted that during the polar winter, in the total absence of solar radiation, the chemical activity of the snow is nil, as the snowpack is in a dormant state.

At Concordia station (75°S) on the Antarctic plateau, we have been monitoring the chemical activity of NOx, O3 and nitrate in the snowpack for some fifteen years. Far from being asleep, observations show that there is chemical activity in winter, suggesting NOx production in the middle of the polar night. I will present the observations that tend to demonstrate this activity and put forward several possible explanations.

Ksenija Vučković: Microbial Biodiversity of Precipitation in the Northern Antarctic Peninsula: Observations during Summer and Implications for Winter

(Ksenija Vučković, Interdisciplinary Centre of Marine and Environmental Research (CIIMAR), University of Porto, Matosinhos, Portugal, Faculty of Sciences, University of Porto, 4150-1, Porto, Portugal

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Irina Gorodetskay, Interdisciplinary Centre of Marine and Environmental Research (CIIMAR), University of Porto, Matosinhos, Portugal)

Estimations of the global aerosol budget remain a major source of uncertainty in climate modelling. With limited observational data in the Antarctic Peninsula (AP) and the Southern Ocean, cloud models struggle to accurately represent current and future climate changes in the AP.

One key uncertainty in cloud modelling is the representation of bioaerosols. The atmosphere over the AP is unique due to its distance and isolation from human sources of atmospheric pollutants, making it largely dominated by biogenic aerosols. These natural aerosols are primarily produced through complex interactions between biological emissions, biogeochemical processes, and sea spray production, originating from both local and long-range sources (Mallet et al., 2023). Bioaerosols influence precipitation formation by acting as ice-nucleating particles (INPs) and cloud condensation nuclei (CCN). However, there is a significant knowledge gap regarding the biodiversity of bioaerosols in the AP, their role in precipitation processes, and how they should be incorporated into cloud models.

To address this, we analyse culturable bacteria present in precipitation samples - rainfall, snowfall, and surface snow following precipitation events - collected on King George Island, northern AP during four consecutive summer seasons 2022-2025. Collins glacier snow samples in 1-m snow pits are analysed for comparison and represent accumulation over preceding months possibly including end of winter. We used four different growth media, including Reasoner's Agar, specialised for oligotrophic bacteria adapted to the nutrient-scarce atmosphere of the AP, and Marine Agar, which captures bacteria from marine sources. Bacterial isolates were identified using 16S rRNA gene sequencing, revealing key differences in culturable biodiversity between rainfall and snowfall. First results based on February 2022 and 2023 samples showed that genera known for ice-nucleating activity, such as Pseudomonas sp. and Stenotrophomonas sp., were predominantly recovered from rainfall. Surface snow samples exhibited the highest culturable biodiversity, including Spirosoma and Bacillus strains, which are well-adapted to extreme aerial environments.

Analysis of moisture transport and air mass origins associated with sampled precipitation events indicates potential aerosol origins from the Pacific and Atlantic oceanic regions, most probably associated with sea spray. In winter, local sources of sea salt aerosols in the AP originating from blowing snow on top of sea ice are expected to be stronger compared to summer months (Frey et al., 2020). We hypothesise that winter bioaerosols may also be primarily sourced from blowing snow rather than long-distance atmospheric transport. By comparing microbial biodiversity in precipitation and surface snow samples using specialised growth media, we establish a basis for future studies on winter bioaerosols. The composition of winter bioaerosols remains completely understudied - more interdisciplinary efforts, including field campaigns during the Antarctic winter, will be crucial for improving our understanding of bioaerosols and their role in the changing climate of the AP.

Lise Dekoster: The Role of Mesoscale Eddies on the Formation and Dissipation of Marine Heatwaves in the Southern Ocean in a Changing Climate (POSTER)

(Lise Dekoster, University of Liège, Belgium)

Marine heatwaves (MHWs) in the Southern Ocean exert increasing pressure on marine ecosystems and, when occurring near the Antarctic coast, may also contribute to ice shelf melt. The goal of this project is to investigate the potential role of mesoscale processes, such as eddies, in driving marine heatwaves and their impact on the formation and dissipation of these events. A deeper understanding of these phenomena will improve climate predictions at various scales. Additionally, this study will enhance our understanding of how extreme events like MHWs are represented in reanalysis data.

As an initial step, MHWs in ice-free regions of the Southern Ocean are analysed, focusing on their frequency, intensity, and duration based on the MHW definition by Hobday et al. (2016). Currently, the ESA SST CCI (European Space Agency Climate Change Initiative) sea surface temperature dataset is being used to detect marine heatwaves south of 60°S. Next, in areas sensitive to marine heatwaves, the eddy kinetic energy, the number of eddies, their cyclonic or anticyclonic nature, and other relevant characteristics are assessed to determine whether mesoscale eddies play a role in driving MHWs. Finally, the influx of freshwater resulting from sea ice melt over time is examined to evaluate its influence on both MHWs and mesoscale eddies.

This study relies on a combination of satellite data (SST and altimetry), model simulations, reanalysis data, and in situ observations. The goal of this presentation is to stimulate discussions with attendees, which will help further develop my understanding of marine-atmosphere coupling and its implications for marine heatwave processes.

Ľubica Vetráková: Ice under the Microscope: Investigating the Origin of Salt Aerosols (POSTER)

(Ľubica Vetráková, Institute of Scientific Instruments of the Czech Academy of Sciences, Brno, Czech Republic

Kamila Závacká, Institute of Scientific Instruments of the Czech Academy of Sciences, Brno, Czech Republic

Vilém Neděla, Institute of Scientific Instruments of the Czech Academy of Sciences, Brno, Czech Republic

Xin Yang, British Antarctic Survey, Natural Environment Research Council, Cambridge, UK

Dominik Heger, Department of Chemistry, Masaryk University, Brno, Czech Republic)

Ice plays a crucial role in our environment. Not only it serves as a vital habitat for polar wildlife and helps regulate the climate, it also acts as a reservoir for anthropogenic pollutants. These pollutants can accumulate, be stored, undergo (photo)transformation into species with varying toxicity, and eventually be released back into aquatic ecosystems. Understanding these processes requires detailed knowledge of the ice morphology and how it varies based on the freezing method used.

In our laboratory, we employ advanced environmental scanning electron microscopy (A-ESEM) to investigate ice and frozen aqueous solutions. Using our self-customized microscope, we capture detailed images of the morphology of frozen samples and identify the distribution of impurities within the ice based on the freezing method. The ability to vary temperature and humidity in situ enables us to observe dynamic transformations in ice samples, such as phase transitions, sublimation, and condensation.

Recently, we used the A-ESEM technique to elucidate the mechanism of the formation of small aerosolizable salt particles from salty frozen samples.1,2 In polar regions, salt aerosols are important to polar atmospheric chemistry. However, the exact source the aerorosols was previously poorly understood and not well quantified. Therefore, we inspected the number, size, and structure of the particles that remain after ice sublimation as a function of the concentration of the salt in the sample, the freezing method, and the sublimation temperature. We showed that the sublimation temperature was the most important factor for formation of small aerosolizable particles: their formation was generally restricted when ice sublimation proceeded above eutectic temperature when the brine was still liquid. Fine salt particles, a possible source of salt aerosol, were detected only during sublimation of low-salinity samples below eutectic temperature.

Previously, saline frost flowers were assumed to be an effective source of sea salt aerosols. However, our microscopic observations contradicted this assumption due to frost flowers' higher temperature and very high salinity. On the other hand, cold multiyear sea ice and low-salinity snow lying on aged ice are more likely to be a direct source of fine salt particles that may become aerosols when windblown. Our qualitative and quantitative analysis of sea salt aerosol formation may bring more light into future investigation of polar spring ozone depletion and bromine explosion events.

Magdalena Muir: Changes and Trends for Atmospheric Rivers for Arctic and Mid Latitudes of Western North America

(Magdalena Muir, Bamfield Marine Sciences Centre and Research Associate, Arctic Institute of North America, Canada)

Atmospheric rivers are long narrow bands of atmospheric moisture, forming rivers of atmospheric moisture in the sky. For western North America, they originate in tropical and subtropical regions of the Pacific Ocean, bring vapour from as far away as the islands of Hawaii. When these atmospheric rivers reach the Rocky Mountains, it rises, cools and condenses resulting in heavy precipitation, either rain or snow, depending on the temperature.

The presentation will consider the impacts of atmospheric rivers on western North America, including: snow depth, melting of sea ice and moisture in the Arctic; flooding and rivers in the Pacific Coastal Region and interior mountain ranges; and avalanches, snowpack, and snow melt in the Rocky Mountains and great plains region of North America.

The presentation will also consider global and regional climate impacts and trends on atmospheric rivers for western North America, which may affect the frequency, width and intensity of atmospheric rivers.

Mark Tarn: Ice-nucleating particle measurements during the Southern Ocean Clouds research cruise

(Mark D. Tarn, School of Earth and Environment, University of Leeds, UK

Imogen Wadlow, School of Earth and Environment, University of Leeds, UK

Manuel Dall'Osto, Institut de Ciències del Mar (CSIC), Spain

Amélie Kirchgaessner, British Antarctic Survey, UK

Thomas Lachlan-Cope, British Antarctic Survey, UK

Benjamin J. Murray, School of Earth and Environment, University of Leeds, UK)

Climate models suggest that biases in surface radiation and sea surface temperature over the Southern Ocean are the largest anywhere in the world, severely impacting on our ability to predict global climate. Evidence suggests that these biases are due to the poor representation of mixed-phase clouds in the region, including the role of ice-nucleating particles (INPs). INPs are a rare aerosol type that can trigger the freezing of supercooled cloud water droplets, substantially influencing the lifetime and radiative properties of mixed-phase clouds. To better understand the role of INPs in a changing climate it is crucial to know their sources and concentrations in the present, but there is a distinct lack of INP measurements from the Southern Ocean.

We have taken the first ever set of real-time continuous INP measurements around the Antarctic Peninsula and South Sandwich Island regions during the Southern Ocean Clouds (SOC) research cruise. The cruise took place aboard the RRS Sir David Attenborough in the early austral summer of 2024 over a period of 5 weeks, covering an area from 50 S to 67 S and 70 W to 25 W. Online INP measurements were collected every 6 min using the Portable Ice Nucleation Experiment (PINE) chamber. The PINE chamber generates clouds from ambient air by adiabatic expansion and monitors the ice particle concentrations, allowing for INP measurements across a range of temperatures. Online measurements of ambient aerosol size distributions were collected simultaneously, alongside real-time bioaerosol monitoring via a Plair Rapid-E. The ambient INP measurements were further supported by traditional aerosol filter sampling methods and droplet freezing assay analysis. Measurements of seawater INPs were also performed throughout, and their potential contribution to the ambient INP population was investigated.

Here, we will discuss the ambient INP measurements from throughout the SOC cruise and discuss trends and potential sources.

Markus Frey: Should clouds care about aerosol from blowing snow above sea ice during Arctic winter/spring?

(Markus Frey, British Antarctic Survey, Natural Environment Research Council, Cambridge, UK

Floortje van den Heuvel, Amélie Kirchgäßner, Simran Chopra, Megan Malpas, Tom Lachlan-Cope, Ronny Engelmann, Heike Wex, Jessica Mirrielees, Kerri Pratt, Julia Schmale, Ivo Beck, Xianda Gong, Matthew Shupe, Ian Brooks, Kouichi Nishimura)

Aerosols play a key role in Arctic warming via radiative direct and indirect effects. It is well-known that increased aerosol concentrations due to Arctic haze raise cloud longwave emissivity, resulting in surface warming. Recently, a MOSAiC study demonstrated that blowing snow above sea ice generates fine sea salt aerosol, which results in up to tenfold enhancement of cloud condensation nuclei leading to potentially significant surface warming rivalling that due to Arctic haze. Yet, radiative properties of aerosol emitted by sea ice sources, vertical coupling and interaction with clouds remain major uncertainties in quantifying the aerosol impact on Arctic climate change.

We use MOSAiC observations to analyse the coupled ocean-ice/snow-atmosphere system and assess contributions of sea ice sources (blowing snow, open leads) to atmospheric cloud-forming particles in particular ice-nucleating particles (INP). Choosing the 2020 winter/spring transition with profound seasonal changes in sea ice and air mass origin, we discuss the importance of sea ice aerosol to low-level clouds in comparison to advected aerosol. We consider measurements of snow particles, physico-chemical properties and INP content of aerosol and snow on sea ice, vertical profiles linking ground observations to the level of cloud formation.

Martin Radenz (KEYNOTE): Advancing observations of aerosol-cloud interaction during polar winter with remote sensing

(Martin Radenz, Leibniz Institute for Tropospheric Research, Leipzig, Germany

Ronny Engelman, Leibniz Institute for Tropospheric Research, Leipzig, Germany

Holger Baars, Leibniz Institute for Tropospheric Research, Leipzig, Germany

Albert Ansmann, Leibniz Institute for Tropospheric Research, Leipzig, Germany

Hannes Griesche, Leibniz Institute for Tropospheric Research, Leipzig, Germany

Cristofer Jimenez, Leibniz Institute for Tropospheric Research, Leipzig, Germany

Patric Seifert, Leibniz Institute for Tropospheric Research, Leipzig, Germany)

Our understanding of aerosol sources, processes and sinks, the interaction with clouds and the impact on radiative budget and precipitation during polar winter is still limited. One crucial problem is the lack of comprehensive observations in the polar regions, covering the atmosphere from the ground up to the stratosphere. During the last years, a couple of ground-based remote-sensing datasets were collected at locations, that were not covered previously. The talk will focus on two activities, where the ACTRIS mobile exploratory platform OCEANET-Atmosphere was a core component.

Firstly, the one year drift during MOSAiC, where OCEANET-Atmosphere was installed on bord of RV Polarstern. Secondly, the deployment to Neumayer Station III, Antarctica (70.67°S, 8.27°W) in 2023, where it was operated on the Ekstrom ice shelf. It will be shown, how the combination of multiwavelength Raman polarization Lidar, cloud radar, scanning Doppler lidar and microwave radiometer provides crucial insights into the microphysics of clouds, aerosol and precipitation. Advanced retrievals of cloud-relevant aerosol properties from optical properties, cloud droplet properties from the dual field of view method together with the ice microphysics obtained by combining radar and lidar observations, allow the detailed characterization of processes in mixed-phase clouds.

Highlights include the frequent occurrence of haze conditions also during winter, both in the central Arctic as well as in coastal Antarctica. For the Artic winter it could be shown, that long-range transport of wildfire smoke can affect ice cloud formation in the upper troposphere. Regarding precipitation at the coast of Antarctica, the observations show strong influence of warm air intrusions on precipitation rate and formation pathways.

Finally, an outlook will be given on currently ongoing and future activities, such as the continuation of ground-based observations at Neumayer and the spaceborne observations by EarthCARE.

Melanie Fuelster: Large-scale atmospheric processes leading to fast ice breakout events in McMurdo Sound in winter 2022

(Melanie Fülster, WSL Swiss Federal Institute for Snow and Avalanche Research SLF, Davos, Switzerland, Institute for Atmospheric and Climate Science, ETH Zurich, Zurich, Switzerland

Ruzica Dadic, WSL Swiss Federal Institute for Snow and Avalanche Research SLF, Davos, Switzerland

Iris Thurnherr, Institute for Atmospheric and Climate Science, ETH Zurich, Zurich, Switzerland

Heini Wernli, Institute for Atmospheric and Climate Science, ETH Zurich, Zurich, Switzerland)

The McMurdo Sound, located in the Ross Sea, Antarctica, is characterised by landfast sea ice, i.e., sea ice attached to the coast. While the fast ice in the Sound typically forms a stable cover around April, the winter of 2022 saw a significant delay in its development, which was caused by repeated ice breakout events. A stable sea ice cover did not form until late August, which had implications for logistical and scientific sea-ice operations in the area.

This project aims to identify the large-scale atmospheric processes responsible for the delayed formation of a stable fast ice cover in McMurdo Sound in winter 2022. Satellite imagery and sea-ice concentrations generated by the ARTIST sea ice algorithm are used to determine fast-ice breakout events in McMurdo Sound. We use ERA5 reanalysis data to explore the synoptic situation leading to and during these breakout events. Our analysis provides insight into the synoptic processes leading to the outbreaks that delay the development of a stable fast-ice cover.

Ola Persson (KEYNOTE): Air-Ice-Ocean Coupling During Cyclone Events in the Central Arctic

(Ola Person, Cooperative Institute for Research in Environmental Sciences/NOAA/ESRL; University of Colorado; D. Watkins, T. Stanton, J. Haapala, A. Solomon, M. Shupe, G. Svensson, and J. Hutchings)

Studies over the last decade have suggested that both thermodynamic and dynamic interactions between the atmosphere and the underlying sea ice are significant during Arctic cyclone events, and that impacts on the upper ocean also occur. Mid-winter thermodynamic interactions include warming of the sea ice surface through enhanced longwave radiative fluxes, often leading to thermal waves penetrating the sea ice and reducing mid-winter ice growth rates. Longwave thermodynamic forcing also destabilizes the atmospheric boundary layer through surface warming as a cyclone approaches and by cold-air advection behind the departing cold front. The sudden, rapid destabilization behind the cold front greatly enhances the dynamic interaction between the atmosphere and sea ice through the enhanced air-ice stress occurring during this unstable period. This enhanced stress greatly impacts ice motion and deformation, which in turn, through drag on the upper ocean, impacts upper ocean currents. These enhanced air-ice stresses appear to be associated with atmospheric low-level jets observed with Arctic cyclones. The surface energy budget equation provides a framework for the thermodynamic interactions, while the ice momentum equation similarly provides a framework for the dynamic interactions.

Cyclones from several field programs have shown these air-ice-ocean interactions, though only two (SHEBA 1997-1998 and MOSAiC 2019-2020) have captured details of wintertime events in the Central Arctic. This presentation will focus on observations obtained during one of these, the Multidisciplinary Observatory for Study of the Arctic Climate (MOSAiC) field program from Oct 2019 to Sep 2020, to illustrate these thermodynamic and dynamic air-ice-ocean interactions. Furthermore, the ability of a coupled model to faithfully represent some of the observed air-ice and ice-ocean interactions is examined for one midwinter case.

Patrick Martineau: Projected Amplification of Moisture Fluxes towards Antarctica by Synoptic Eddies (POSTER)

(Patrick Martineau, Japan Agency for Marine-Earth Science and Technology, Yokohama, Japan

Hua Lu, British Antarctic Survey, Cambridge, UK

Thomas Bracegirdle, British Antarctic Survey, Cambridge, UK)

Synoptic weather systems play a significant role in transporting moisture to Antarctica, which affects snow and ice accumulation and, consequently, global sea levels. The latest generation of climate models predict significant changes in these systems' activity, including a hemisphere-wide increase during winter and a poleward shift during summer, which could have crucial implications for the Antarctic ice mass balance. Our findings indicate that current climate models forecast a substantial increase (~5% per decade) in synoptic moisture fluxes across the Antarctic Circle in the lower troposphere. This increase is primarily due to higher moisture content in these weather systems rather than the increase in synoptic wind variability, which is typically used to evaluate storm track amplification and shifts.

Peter Convey: Storm-driven 'rain-on-snow' events in the polar winter have important consequences in terrestrial ecosystems

(Peter Convey, British Antarctic Survey, Cambridge, UK

Larissa Beumer, University Centre in Svalbard

Simone Lang, University Centre in Svalbard

Steve Coulson, University Centre in Svalbard)

Climate models predict continued rapid warming of the Arctic, with altered seasonality and an increased frequency of extreme weather events. Such changes are already evident in studies of terrestrial ecosystems on Svalbard. These include a regime shift towards more precipitation falling as rain in winter, with some storm events resulting in many months' precipitation falling in only a few hours. Since 1998, mild and rainy winters with basal ice formation on the ground surface have occurred almost annually on Svalbard, a considerable increase on the previous average of once every 3–4 years. The formation of such basal ice layers has important consequences for many elements and processes in polar terrestrial ecosystems. For instance, rain-on-snow events have been associated in some studies with extreme dieback of vascular plants and reduced annual growth. They contribute to changes in the depth and distribution of snow cover, altering the exposure of terrestrial plants, invertebrates and microbial communities to freezing and temperature extremes, as well as affecting the thermal regime of the underlying permafrost. Experiments mimicking winter basal ice formation have demonstrated taxon-specific consequences for the soil fauna, with some groups being negatively affected while others appear robust to the change. The ice layer can encase organisms and soils, and lead to progressive development of anoxia in the underlying habitats, again with negative consequences for soil fauna and microbiota. The encasement of plants in ice in winter limits the abundance of grazing vertebrates, such as Svalbard reindeer, through negative density-dependent effects on body mass, survival and reproduction, and can cause considerable mortality. Increased precipitation falling as rain is also a feature of contemporary climate change in the Antarctic Peninsula region, where changed patters of storm events can lead to large amounts of precipitation over short periods. At present these largely occur in the austral summer months, but also have important biological consequences, including the washing out of snow cover and its contained microbial communities, and sometimes significant mortality events through waterlogging and chilling of eggs or young in vertebrate breeding colonies. However, short winter thaw events are also recorded in these regions, leading to potentially analogous consequences for underlying terrestrial plant, invertebrate and microbial communities as already observed in the Arctic.

Qigang Wu: Significant Weakening Effects of Winter Polar Front Jets and Tropospheric Vertical Wind Shear by Future Arctic Sea Ice Loss (POSTER)

(Qigang Wu, Department of Atmospheric and Oceanic Sciences, Fudan University, Shanghai, 200438, China)

The potential influences of observed and projected Arctic sea ice loss on the midlatitude weather and climate have been extensively examined, but strongly debated. Our recent observational and modeling studies consistently suggest that Arctic sea ice loss significantly contributed to observed Arctic warming and reduced meridional temperature gradient between midlatitudes and the pole in the lower and middle troposphere, acting to weaken westerly wind on the poleward side of the polar front jet (PFJ) in winter (summer) on the Eastern (Western) Hemisphere since 1980s. This study further examines four time slice experiments forced by present sea surface temperature (SST) and preindustrial or future Arctic sea ice concentration (SIC) with or without interactive oceans from four CMIP6 models, and answer two questions: (1) whether future Arctic sea ice loss will significantly weaken the Western Hemisphere winter PFJ; (2) whether ocean coupling matters for the winter PJF responses to future Arctic sea ice loss. Ensemble mean effects of four models and each model due to future Arctic sea ice loss induces significantly weakened winter PJF and tropospheric vertical wind shear in both hemisphere. Dynamical and thermodynamic oceanic feedbacks significantly amplify the response of the Eastern Hemisphere PJF to future Arctic sea ice loss only in CESM1-WACCM model, but not in other three models. The responses of Western hemisphere PFJ and high-latitude hemispherical zonal-mean zonal winds shows less sensitivity to the degree of ocean coupling in all four models. Overall, our results suggest that a dynamical pathway linking observed and future Arctic sea ice loss to northern winter is through its weakening effect on the westerly wind on the poleward side of the PFJ and tropospheric vertical wind shear.

Radim Štůsek: Freezing-induced acidification of sea ice brine

(Radim Štůsek, Masaryk University, Faculty of Science, Department of Chemistry, Czech Republic

Lukáš Veselý, Masaryk University, Faculty of Science, Department of Chemistry, Czech Republic

Xin Yang, British Antarctic Survey, UK Research Innovation, Cambridge, UK

Dominik Heger, Masaryk University, Faculty of Science, Department of Chemistry, Czech Republic)

The polar regions represent a chemically rich environment with a number of acid-catalyzed reactions, the most prominent of which is perhaps the photochemically assisted release of reactive bromine from particulate-phase bromide in polar regions, especially during early spring. The so called bromine explosion event may significantly affect atmospheric oxidising capacity, e.g. causing surface ozone depletion and oxidising elemental mercury.

One proposed source of reactive bromine is from the surface of acidic sea salt aerosols originating from blowing snow above first-year sea ice. So far, it has been thought that the enhanced acidity of the sea salt aerosols is caused by the anthropogenic acids (e.g., HNO3, and H2SO4) scanvenged from the atmosphere. In addition to to this hypothesis we uncovered a new natural source of acidity by freezing seawater, which produces acidic brine that can subsequently wet the icy particles and turn the originally alkaline particles into acidic ones. The finding supplies a new pathway to produce acidic aerosol particles in prinstine polar regions and during pre-industrial era.

We achieved the measurement of brine acidity by freezing the seawater with a small addition of an acid-base indicator, thus creating an in-situ acid-base probe, the protonation of which can be assessed spectroscopically. We found that freezing of the slightly alkaline (pH = 8) seawater at -15 °C will result in significant acidification (pH = 7-6.5) of the remaining concentrated brine mainly due to the precipitation of carbonates, further cooling may cause freeze-concentration of the slightly acidic solution, acidifying it to values as low as pH = 5. Thawing, on the other hand, will result in return of the pH towards the original values of pH=8.

Raven Quilestino-Olario: Winter marine thermal extremes in East Antarctica and their spatiotemporal differences across multiple baselines (POSTER)

(Raven Quilestino-Olario, Institut für Geologie und Mineralogie, Universität zu Köln, 50674 Köln, Germany

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Marine heatwaves/cold-spells (MHWs/MCSs) are unusually warm/cool extreme events being investigated for their potential significant impact on ocean ecosystems. However, research gaps — more regional studies on the Arctic than the Antarctic, more summer analyses, and an ongoing debate on baseline appropriateness — hinder understanding of MHWs and MCSs in the Southern Ocean. We used the Operational Sea Surface Temperature and Ice Analysis (OSTIA) system to detect marine thermal extremes within the Indian and Western Pacific sectors of the Southern Ocean (50-75°S; 20-160°E). Events are detected using the framework baseline climatology of 30 years (1982-2011) and a climatology using the full 43-year time series data (1982-2024), which were filtered further within the coastal Antarctic winter months (April-September). Seasonal distribution reveals that the 30-year-baseline calculation produced more winter MHWs and MCSs (>50%), while the 43-year-baseline favoured summer conditions instead (October-March). Month-wise, 30-year-baseline events were more frequent, had longer existence, but were weaker than 43-year-baseline events. MHWs have stronger metrics at the start of winter and would dwindle towards September, while MCSs usually prevail during mid- and late-winter months. Annually-averaged metrics display how winter MHWs have an increasing frequency and duration trend rates greater than winter MCSs in both baselines, akin to global trends. Additionally, yearly trends show distinguishable warming (2007, 2012, 2017) and cooling (2008-11, 2013-16) periods. Spatial patterns are also identified where most values decrease using the 43-year-baseline climatology. Sea-ice zones near the coast have more prevalent MHW increases with 30-year-baseline, but also clear MCS increases with 43-year-baseline climatology. The central part near Kerguelen Plateau is also seen to consistently show stronger MHW, weaker MCS trends during winter. Generally, this work highlights how changing baselines reflect effects of long-term warming in climate analysis even in Antarctica, and deeper comprehension of MHWs/MCSs within this region would merit further analysis with ocean-atmospheric factors.

Ross Herbert: Low-latitude dust emitted in summer months may impact polar winter INP availability

(Ross Herbert, ICAS, University of Leeds, Leeds, UK

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For most regions of the world, the availability of mineral dust particles drives the production of primary ice in mixed-phase clouds. The mineral dust acts as an ice nucleating particle (INP), which facilitates the freezing of supercooled cloud droplets at higher temperatures than in its absence (~ -38C). During polar winter there are few localised sources of dust in the high latitudes, therefore transport from lower latitudes becomes an important source of mineral dust and INPs in the polar regions.

In this study we identify a previously overlooked source of low-latitude dust: those from long-lived dust in smaller size modes that have been in the atmosphere for up to 5 months.

Using a series of 'decay' simulations of the UK Earth System Model (UKESM), we find that although fresh dust contributes most of the dust mass in the polar regions, the INP contribution is weighted towards the older, smaller, dust particles. The Southern Ocean and Antarctica are particularly sensitive, with long-lived dust over 60 days since emission contributing over 50 % of all dust INPs in the winter. The Arctic is more sensitive during the late summer, but long-lived dust still provides an important source of INPs during the winter months that may characterise background INP availability. The results have implications for what sized particles we deem important for characterising INP availability. Close to primary dust sources, the INP concentration is dependent on the super-micron particles, whereas far from the source (i.e. the polar regions and remote oceans) the INP concentration is dependent on the smaller, older, sub-micron particles.

Satyajit Singh Saini: Impact of Aeolian Transported Black Carbon and Dust Aerosols on Antarctic Ice Sheet Albedo and Melting Dynamics

(Satyajit Singh Saini, Indian Institute of Technology Roorkee, India

Dhyan Singh Arya, Indian Institute of Technology Roorkee, India

Anand Kumar Singh, National Centre for Polar and Ocean Research, Goa, India)

The deposition of light-absorbing aerosols, particularly black carbon (BC) and dust, near Antarctic research stations significantly influences surface albedo, leading to enhanced absorption of solar radiation and fastened melting. This study investigates the aeolian processes responsible for transporting BC and dust to Antarctica, their atmospheric concentrations, and subsequent effects on ice sheet albedo and melt rates.

Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model was used to trace BC aerosol pathways originating from lower latitudes to the vicinity of the study area and identifying the atmospheric mechanisms which facilitate long-range transport. Atmospheric aerosol concentrations were measured using an Aethalometer at Antarctic research station Bharati to assess seasonal variability. Dust aerosol concentrations were analysed using MODIS satellite data, providing insights into the spatial and temporal distribution of mineral dust near the Antarctic ice sheets. This work also traced atmospheric rivers (ARs) as potential transport pathways carrying BC and dust particles from continental sources to polar regions. The Snow, Ice, and Aerosol Radiation (SNICAR) model was applied to simulate the radiative forcing induced by BC and dust deposition, which will help in quantifying their impact on energy balance of snowpack. Preliminary findings suggest that BC and dust deposition during polar winters, followed by exposure during melt seasons, leads to a measurable decrease in surface albedo, thereby increasing melt rates. The influence of ARs in transporting aerosols and moisture to polar regions highlights the importance of understanding aerosol-cloud interactions. These results underscore the need for enhanced monitoring and modelling of aerosol deposition and radiative forcing in polar environments.

Sergi Gonzalez-Herrero: Physical insights on winter heatwave intensification of the March 2022 event in Antarctica using Pseudo-global warming simulations

(Sergi González-Herrero, WSL Institute for the Snow and Avalanche Research SLF, Switzerland

Sihan Li, University of Sheffield, UK

Prenab Deb, IIT Kharagpur

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Antarctica has experienced several very extreme heatwave events in recent years. However, whether and to what the extent climate change influences these events remains uncertain, specially during the winter months when temperatures are typically well below freezing across the continent. Here we present a climate change attribution analysis of the March 2022 heatwave, triggered by a strong atmospheric river event, which led to a sudden temperature raise of ~40° C in three days at Concordia station. Using pseudo-global warming simulations with the atmosphere-cryosphere coupled model CRYOWRF, we gain insights into the physical processes that influenced the event. Results show that climate change enhanced water-vapour and cloud mixing ratio around Dome C amplifying the intensity of the heatwave by approximately 25%. Simulations with future projections by the end of the century indicate that a similar event would no longer amplify the heatwave at the dome. Instead, the warming amplification would spread to nearby regions following mechanisms similar to those that currently amplify heatwaves at Dome C.

Tom Bracegirdle (KEYNOTE): Antarctic weather and climate extremes in a warming world, recent research progress and future priorities

(Tom Bracegirdle, British Antarctic Survey, Cambridge, UK)

In this talk I will provide an overview of the current state of knowledge on extreme weather and climate events in Antarctica, the major current knowledge gaps and the research required to address these. Extreme seasons (climate extremes) are of particular relevance to impacts, as they can produce accumulated effects on, for example, surface melt of ice shelves and penguin breeding. There is a gap in knowledge on how extreme seasons may change over Antarctica and the Southern Ocean under future climate forcing scenarios, with Antarctica not included in the IPCC AR6 WG1 Chapter 11 on extremes. Recent research utilising large ensemble datasets of climate model simulations has provided an initial multi-variate overview of the evolution of extreme seasons over Antarctica and the Southern Ocean during the 20th and 21st centuries. However, in order to study shorter-timescale extreme weather events and their impacts, new modelling capabilities, both dynamical and statistical, are being developed to downscale the output from large ensembles to impacts-relevant spatial scales. Current research towards this as part of projects such as ExtAnt will be described.

Varunesh Chandra: Dynamics of High-Latitude Atmospheric Blocking and Teleconnection to North American Winter Extremes: A viewpoint from potential vorticity gradient

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High-latitude atmospheric blocking plays a crucial role in modulating North American winter weather extremes. In particular, the Alaskan Ridge and Greenland Blocking are key features that influence downstream and upstream circulation and contribute to cold-air outbreaks. During major ridging events over Alaska in 2018 and 2019, record-low sea ice, persistent warm anomalies, and ecosystem disruptions were observed, along with a downstream teleconnection to enhanced troughing and cold extremes over North America. Based on a nonlinear multi-scale interaction (NMI) framework, we examine the genesis and persistence of these blocking events, which are associated with small or negative meridional potential vorticity gradients (PVy). NMI theory suggests that negative PVy leads to a reduction in zonal wind speed and synchronization of synoptic, blocking, and background flow time scales, favouring prolonged atmospheric blocking. Case studies reveal frequent occurrences of negative PVy during January and February, though not continuously. A climatological analysis from 1979 to 2023 indicates that negative PVy events are ubiquitous in mid-winter, typically persisting for several days to a week, while month-long dominance is rare. Composite analysis of 500 hPa geopotential heights and 2m air temperature anomalies for negative PVy days confirms a robust Alaskan Ridge, and Greenland Blocking structure coinciding with cold anomalies over the central and eastern United States. These findings highlight the critical role of potential vorticity dynamics in maintaining atmospheric blocking and their implications for winter weather variability.

Wen Zhou: A frequent ice-free Arctic is likely to occur before the 2050s

(Wen Zhou, Fudan University, China)

Despite extensive research on the trend of sea-ice extent under global warming in recent years, most climate models have struggled to accurately capture the recent rapid changes in the Arctic environment. This raises concerns about the reliability of climate model projections for sea ice and suggests a possible shift in Arctic climate dynamics. Using a time-variant emergent constraint method with a weighting scheme, our findings indicate that an ice-free Arctic may occur at least 5 to 10 years earlier than previous estimates. In other words, Arctic sea ice is likely to disappear before the 2050s.

Observationally constrained projections suggest that under a fossil-fuel-based development scenario (Shared Socioeconomic Pathway (SSP) 5–8.5), an ice-free Arctic in September is most likely to occur between 2050 and 2054, with a 66% confidence range (equivalent to the IPCC's 'likely' range) of 2037–2066. Under more moderate mitigation scenarios (SSP2-4.5 and SSP3-7.0), an ice-free Arctic would likely be delayed by approximately 20 years and 11 years, respectively. However, in the sustainable development scenario (SSP1-2.6), an ice-free Arctic is unlikely to occur.

Looking ahead, this time-variant emergent constraint approach could also serve as a valuable tool for detecting tipping points in the climate system.

Xianda Gong: Local Blowing Snow Surpassing Long-range Transported Pollution on Aerosol Loading and Surface Warming in the Arctic

(Xianda Gong, Westlake University, China)

Arctic temperature increased nearly four times faster than the global average. Aerosols' direct and indirect effects play a critical role in Arctic climate change. Previous studies focus on long-range transported pollution during winter and spring seasons in the Arctic, however, recent observations suggest that blowing snow is another significant contributor to aerosol loading. Here, we identify background periods and enhanced aerosol number concentration events from November 2019 to April 2020 and distinguish enhanced aerosol concentration events into blowing snow and long-range transported pollution dominant events, respectively. Blowing snow events contribute nearly four times Aitken and twice the accumulation mode particle concentrations compared to these during background periods, surpassing the contributions of long-range transport pollution events. These aerosols further serve as cloud condensation nuclei and influence cloud formation, leading to smaller cloud droplets and higher cloud albedo. When only considering the aerosol first indirect effect, blowing snow events significantly contribute to Arctic surface warming, with an average longwave radiative forcing of +4.98 W m-2, exceeding the +2.82 W m-2 attributed to long-range transport pollution.

Xiangdong Zhang: Climatology, Variability, and Changes of Arctic Cyclones and Impacts on Arctic Sea Ice and Ocean

(Xiangdong Zhang, NCICS, North Carolina State University, USA)

Along with the amplified Arctic warming and drastically retreating sea ice, extremely intense cyclones have been more frequently observed throughout the year in the Arctic. These cyclone systems have also, in turn, enhanced air-sea-ice interactions, leading to transient warming and sea ice loss events and cumulatively contributing to the long-term Arctic climate changes. We conduct systematic analysis of Arctic cyclone activity from its climatic variability and changes to process-level studies on selected rare extreme cases using both reanalysis datasets and model simulations. The results indicate that Arctic cyclone activity, measured by an energy-based, integrative index, has intensified during last seven decades, which is supported by the CMIP6 model historical simulations. The underlying physical mechanisms are increased surface baroclinicity due to sea ice retreat and warmed open ocean, as well as the strengthened downward influence of the stratospheric vortex. When examining specific intense cyclone cases, it is found that intense summer cyclone can induce Ekman upwelling, transporting subsurface warm water to the upper ocean, and increase upper ocean mixing. As a consequence, summer sea ice melt accelerates. Further analysis also suggests that higher model spatial resolution captures more numerous cyclones, which is important for understanding the finer-scale interactive processes between cyclones and the underlying sea ice and ocean for creating extreme climate events.

Xin Wang: The Synergistic Impact of the Autumn Barents-Kara Sea and Baffin Bay-Hudson Bay Sea Ice Dipole on South China Spring Precipitation+[@ID]

(Xin Wang, Department of Atmospheric and Oceanic Sciences, Fudan University, China)

South China spring precipitation (SCSP) exhibits pronounced interannual and interdecadal variability, with the El Niño-Southern Oscillation (ENSO) being its dominant but unstable predictor, leading to limitations in single-factor ENSO-based forecasts. This study highlights the critical role of mid-to-high latitude sea ice anomalies in modulating SCSP. Greenland (Gre) and Barents-Kara Sea (BK) sea ice anomalies are inversely correlated with SCSP, while Baffin Bay-Hudson Bay (BH) sea ice shows a significant positive interannual correlation. A multivariate linear regression model incorporating autumn sea ice signals demonstrates predictive potential for SCSP (42-year correlation: 0.44, $P<0.01$), with BH sea ice emerging as the dominant predictor post-2000. Mechanistically, reduced BK sea ice enhances the Middle-East Pacific high, accelerating surface winds over the western Philippine Sea, which triggers wind-evaporation-SST feedback and cold SST anomalies. Increased BH sea ice excites a North Atlantic tripole SST pattern, inducing a southward-shifted Northeast Asian high via atmospheric teleconnection. The resultant easterly anomalies amplify background winds, further cooling the western Pacific. Persistent cold SSTs strengthen the subtropical high via Gill response, while the Atlantic tripole sustains an enhanced East Asian meridional circulation. A "sea ice dipole" (BK−/BH+) synergistically enhances moisture transport via subtropical high and vertical ascent over South China, significantly increasing SCSP. These findings reveal cross-scale interactions whereby mid-to-high latitude sea ice modulates tropical-subtropical circulations, offering new insights into non-ENSO drivers and improving seasonal predictability. The pre-signal role of autumn sea ice underscores its utility in regional climate forecasting, advancing understanding of cross-seasonal air-sea dynamics.

Xinyi Huang: Different responses of cold-air outbreak clouds to aerosol and ice production depending on cloud temperature

(Xinyi Huang, University of Leeds, United Kingdom

Paul R. Field, Benjamin J. Murray, Daniel P. Grosvenor, Floortje van den Heuvel, Kenneth S. Carslaw)

Aerosol-cloud interactions and ice production processes are important factors that influence mixed-phase cold-air outbreak (CAO) clouds and their contribution to cloud-phase feedback. In this study, we use a high-resolution nested model to quantify and compare the responses of cloud microphysics and dynamics in cloud droplet number concentration (Nd), INP concentration and efficiency of the Hallet-Mossop (HM) secondary ice production process in two archetypal CAO events over the Labrador Sea, representing intense (cold, March) and weaker (warmer, October) mixed-phase conditions. Our results show that variations in INP concentrations strongly influence both cases, while changing Nd and the HM process efficiency affect only the warmer October case. With a higher INP concentration, cloud cover and albedo at the top of the atmosphere increase in the cold March case, while the opposite responses were found in the warm October case. We suggest that the CAO cloud response to the parameters is different in ice-dominated and liquid-dominated regimes, and the determination of the regime is strongly controlled by the cloud temperature and the characteristics of ambient INP, which both control the glaciation of clouds.

Yuqing Wang: Global warming has significantly shifted the occurrence of heatwave events into the Antarctic interior

(Yuqing Wang and Wen Zhou, Fudan University, China)

In recent years, extreme heatwaves have increasingly occurred in Antarctica. Our findings indicate that heatwave events have penetrated further into the Antarctic interior due to global warming, signifying that the frequency of heatwaves in the inland regions of Antarctica has risen significantly faster than in the sea-ice regions. Further analysis reveals that anthropogenic activity-related external forcing is the primary driver behind this disparity in increasing rates of heatwaves across Antarctica. Under such anthropogenic external influences, both the western subtropical Pacific, eastern Australia and the South Atlantic have experienced abnormal warming at an accelerated pace. This phenomenon has led to heightened evaporation in lower latitude oceans, a poleward shift of westerly winds, and alterations in atmospheric circulation patterns—facilitating greater influxes of warm and moist air into the Antarctic interior and consequently amplifying heatwave occurrences. However, surface warming on the Antarctic continent also results in a lesser increase in the meridional gradient of surface pressure within sea-ice regions compared to that aloft. As a result, geostrophic wind increases more substantially at higher altitudes than at the surface level, and baroclinicity within the atmosphere is enhanced. This enhancement directly contributes to a slower rates of increase in the frequency of heatwaves over sea-ice regions.

Yuzhuo Peng: Projection of a winter ice-free Barents-Kara Sea by CMIP6 models with the CCHZ-DISO method (POSTER)

(Yuzhuo Peng, Xiamen University, China)

The winter sea ice over the Barents-Kara Sea (BKS) is reducing at an alarming rate, which impacts the Arctic shipping routes and the local ecosystems as well as the climate system across other regions. Consequently, it is imperative to project the winter ice-free state in this region to adequately prepare for future climate change and its impacts. However, most models from the Coupled Model Intercomparison Project Phase 6 (CMIP6) show higher climatological values, weaker decreasing trends, and lower interannual variabilities in winter BKS sea ice concentration compared to observation. Additionally, it can be also seen that there exist great uncertainties in the projections of different models on whether the BKS region will be ice-free in future winters and the ice-free period, which spans almost the entire 21st century. Therefore, the study adopts two approaches developed from distance between indices of simulation and observation (DISO) method to project the winter ice-free period of the BKS under different emission scenarios. The results indicate that under SSP1–2.6, the winter BKS will not be ice-free by 2100. For SSP2–4.5, SSP3–7.0, and SSP5–8.5, the winter BKS is projected to be ice-free during 2076–2086, 2063–2068, and 2049–2061, respectively. By employing the DISO method, the projection uncertainty is reduced and the results highlight the urgency of reducing greenhouse gas emissions to delay the winter ice-free period over the BKS. These projections are intended to provide a reference for policymakers.

Zhaohui Wang: Coupled Influence of Synoptic Weather and Topographic Control on Near-surface Wind Variability in the Denman Glacier Basin, East Antarctica

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Thomas Caton Harrison, British Antarctic Survey, Cambridge, United Kingdom)

Denman Glacier Basin, a critical region for studying polar ice dynamics and climate change impacts, is heavily influenced by the combination of topographic and atmospheric conditions, particularly experiencing strong downslope winds. This study examines the structure and variability of near-surface winds in the basin, focusing on the influence of large-scale circulation, synoptic weathers, and local orographic effects. Through high-resolution atmospheric simulation experiments, we demonstrate the forced components of near-surface winds during prevalent synoptic systems in the area, quantifying the roles of large-scale and locally driven forces in shaping wind structure and variability. We also conduct perturbation experiments with topographies of varying resolutions to examine the orographic controls on the spatial climatology of downslope winds, in response to a range of synoptic systems typical to the region. Our findings can be used to clarify uncertainties in interpreting snow accumulation variability in ice cores and determining whether modern regional mass balance trends result from increased glacial discharge or shifts in synoptic circulation. This research findings will be used to interpret the Denman Glacier discharge, snow accumulation over the basin, aiding in the interpretation of recent ice core data collected in the recent field season.

Zheng-Hang Fu: Seasonal Response of the Tropical Rainbelts to Idealized Antarctic Freshwater Forcing in the SOFIA Multi-Model Ensemble (POSTER)

(Zheng-Hang Fu, Fudan University, China

Wen Zhou, Fudan University, China

Shang-Ping Xie, Scripps Institution of Oceanography, USA

Noel Keenlyside, University of Begen, Norway)

More than 30% of global precipitation occurs within the Intertropical Convergence Zone (ITCZ), and variations in deep convection within this region significantly influence mid-latitude atmospheric circulation. However, coupled climate models in the Coupled Model Intercomparison Project Phase 6 (CMIP6) show substantial discrepancies in trends concerning the intensity and location of the ITCZ when compared to observations. These biases are likely due to the lack of representation of melting Antarctic ice sheets and ice shelves, which contribute to a warm bias in the Southern Ocean. Previous studies have examined the potential influence of the Southern Ocean on the zonal-mean ITCZ and the climatological ITCZ through interhemispheric energy constraints and local ocean-atmosphere interactions. However, the mechanisms driving this influence on basin and seasonal scales remain unclear.

Using the Southern Ocean Freshwater Input from Antarctica (SOFIA) multi-model ensemble, we study the seasonal response of the tropical rain belts to the additional freshwater based on eight coupled climate models. Results show a southward shift of rainfall over the Maritime Continent in the boreal summer, seasonal poleward migration of the North Atlantic ITCZ, and large uncertainties in the changes in the tropical Pacific ITCZ. Our ongoing research aims to address the underlying mechanisms behind these diverse responses across tropical basins based on the local atmosphere-ocean coupled dynamics and heat flux theory.

Zili Shen: Quantifying the relative contribution of internal variability and external forcing on Arctic sea ice variations

(Zili Shen, Fudan University, China)

Two large ensemble simulations are utilized to examine the relative contributions of external forcing and internal variability to Arctic sea ice variability across different time scales since 1960. By correcting model response errors to external forcing using observational datasets, we find that previous approaches may have overestimated the impact of internal variability on Arctic sea ice changes, particularly over longer time scales.

Our findings indicate that internal variability has played a dominant role in Arctic sea ice fluctuations across all time scales throughout the twentieth century in both March and September. However, after the 2000s, the anthropogenic signal in sea ice change becomes steadily and consistently detectable on time scales exceeding 20 years. Additionally, we reveal that the dominant mode of internal variability in March remains consistent across different time scales. In contrast, internal variability in September exhibits significant spatial heterogeneity across the Arctic and varies depending on the time scale, suggesting that different factors drive sea ice variability in September at different temporal scales.