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EXPEDITION PROGRAMME
PS149

Polarstern

PS149
Tromsø - Longyearbyen
02 July 2025 - 01 September 2025

Coordinator: Ingo Schewe

Chief Scientist PS149: Marcel Nicolaus

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Contents

1. ÜBERBLICK UND EXPEDITIONSVERLAUF

Marcel Nicolaus[1], Thomas Krumpen[1] [1]DE.AWI

Die sommerliche Schmelze des Meereises im Arktischen Ozean variiert stark in Raum und Zeit. In den letzten Jahrzehnten hat das Meereis deutlich abgenommen und sich von einer dicken, mehrjährigen Eisdecke zu einer saisonalen Eisdecke gewandelt. Diese Veränderungen wirken sich stark auf den Austausch von Energie, Masse und Impuls zwischen der Atmosphäre und dem Ozean aus und verändern die Zusammensetzung und Funktion der Ökosysteme sowie die biogeochemischen Flüsse. Der dekadische Trend des Meereisverlustes geht mit einer starken interannuellen Variabilität und großen regionalen Unterschieden einher.

Das übergeordnete Ziel der CONTRASTS-Expedition PS149 (ArcWatch-3) ist es, die Schlüsselprozesse zu charakterisieren, die die beobachteten Veränderungen des Meereises, der Ozeane und der Ökosysteme im zentralen Arktischen Ozean während der Schmelzzeit bestimmen. Wir werden die Ursachen und Folgen der Meereisschmelze in drei verschiedenen Meereisregimen als Funktion der atmosphärischen und ozeanographischen Bedingungen untersuchen. Wir werden die Rückkopplungsprozesse in dem gekoppelten System und die relative Bedeutung der Schlüsselprozesse in jedem Regime quantifizieren. Wir werden ihre Rolle im Jahresgang der Meereisbedeckung des zentralen Arktischen Ozeans bewerten. Dies wird es uns ermöglichen, das Verständnis der beobachteten Veränderungen, ihrer Ursachen und möglicher vergangener und zukünftiger Auswirkungen sowie der Auswirkungen auf das Klima, das ökologische und das biogeochemische System zu verbessern. Ein besseres Prozessverständnis wird dazu beitragen, neue und verbesserte Modellparametrisierungen zu entwickeln, einschließlich Beschreibungen über verschiedene zeitliche und räumliche Skalen.

Die Grundlage unseres Messprogramms sind koordinierte Messungen von physikalischen und ökologischen Schlüsselparametern in drei kontrastierenden Meereisregimen, die während der Expedition durch verschiedene Regionen repräsentiert werden:

- Regime 1: Meereis in der Randzone des Eises, das durch einjähriges Meereis gekennzeichnet ist, das sich im letzten Winter/Frühjahr gebildet hat. Es wird erwartet, dass dieses Eisregime den zukünftigen Arktischen Ozean dominieren wird, wenn eine saisonale Eisdecke vorherrscht.
- Regime 2: Meereis, das entlang des transpolaren Driftsystems gedriftet ist, das durch eine Mischung aus erst- und mehrjährigem Meereis gekennzeichnet ist. Das Eis dürfte sich im zentralen Arktischen Ozean gebildet haben. Dieses Eisregime ist ein Hauptbestandteil der heutigen Meereisbedingungen in der Arktis.
- Regime 3: Meereis, das aus dem sogenannten “letzten Eisgebiet” nördlich von Grönland stammt und durch mehrjähriges Eis gekennzeichnet ist. Es hat mehrere Jahre nördlich von Grönland verbracht, während ein Teil des Eises aus dem Beaufort Wirbel System stammen könnte. Dieses Regime ist symbolisch für die vergangene Arktis.

Die Arbeit in jeder Region konzentriert sich auf eine Haupt-Meereisstation, die wir während der Expedition 3-mal besuchen wollen. Bei jedem Besuch werden wir ein identisches Beobachtungsprogramm durchführen, während unserer vorübergehenden Abwesenheit werden autonome Messungen aufgezeichnet. Dies wird es uns ermöglichen, das Atmosphäre-

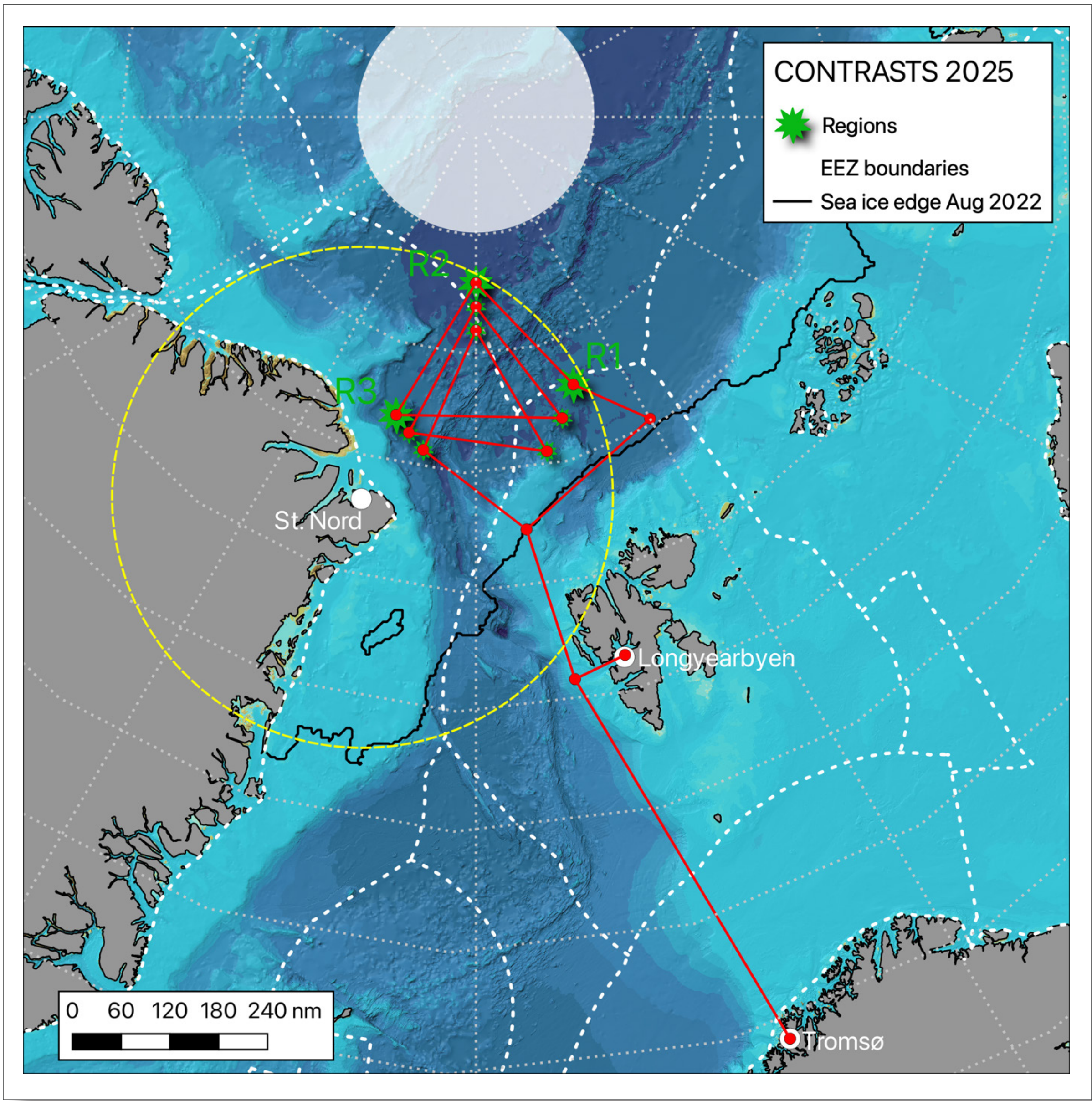

Abb. 1: Geplante Fahrtroute (rote Linien) und Stationen (grüne Sterne) der CONTRASTS-Expedition PS149 (ArcWatch-3). Die Reise beginnt am 2. Juli 2025 in Tromsø und endet am 1. September 2025 in Longyearbyen. Der genaue Verlauf der Reise ist abhängig von der Eis- und Wettersituation im Sommer 2025. Die schwarze Linie zeigt die Meereiskonzentration vom 1. Juli 2024. Die weiß gestrichelten Linien markieren die Grenzen exklusiver ökonomischer Zonen (EEZ) der Anrainerstaaten. Der gelbe Kreis zeigt die Reichweite der Flugkampagne IceBird-summer 2025, die von Station Nord aus geflogen wird.

Fig. 1: Planned route (red lines) and stations (green stars) of CONTRASTS expedition PS149 (ArcWatch-3). The expedition begins on 2 July 2025 in Tromsø and ends on 1 September 2025 in Longyearbyen. The exact expedition track will depend on the ice and weather situation in summer 2025. The black line shows the sea ice concentration on 1 July, 2024. The white dashed lines mark the boundaries of exclusive economic zones (EEZ) of the coastal states. The yellow circle shows the range of the IceBird-summer 2025 flight campaign, which will be flown from Station Nord.

SUMMARY AND ITINERARY

The summer melt of sea ice in the Arctic Ocean varies strongly in space and time. Over the last decades, sea ice has decreased significantly and changed from a thick multi-year ice pack to a seasonal ice cover. These changes strongly impact the exchange of energy, mass and momentum between the atmosphere and the ocean, and alter ecosystem composition and function as well as biogeochemical fluxes. The decadal trend in sea ice loss is combined with strong interannual variability and large regional differences.

The overall objective of the CONTRASTS expedition PS149 (ArcWatch-3) is to characterize the key processes that determine the observed sea ice, ocean, and ecosystem changes in the Central Arctic Ocean during the melt season. We will investigate the causes and consequences of sea ice melt in three different sea-ice regimes as functions of atmospheric and oceanographic conditions. We will quantify feedback processes in the coupled system and the relative importance of key processes in each regime. We will evaluate their role in the annual cycle of the sea ice cover of the Central Arctic Ocean. This will enable us to improve the understanding of the observed changes, their causes and possible past and future impacts, impacts of the climate, ecological and biogeochemical system. A better process understanding will help to develop new and improved model parameterizations, including descriptions over different temporal and spatial scales.

The basis of our field programme are coordinated measurements of physical and ecological key parameters in three contrasting sea ice regimes, represented by different regions during the expedition:

- Regime 1: sea ice in the marginal ice zone, which is characterized by first-year sea ice formed during the last winter/spring. This ice regime is expected to dominate the future Arctic Ocean, when a seasonal ice cover is dominant.
- Regime 2: sea ice that drifted along the Transpolar Drift system, which is characterized by a mixture of first- and multi-year sea ice. The ice should have formed in the Central Arctic Ocean. This ice regime is a major component of today's sea ice conditions in the Arctic.
- Regime 3: sea ice originating from the so-called "last ice area" north of Greenland, which is characterized by multi-year ice. It has spent several years north of Greenland, while fractions of the ice might originate from the Beaufort Gyre system. This regime is symbolic for the past Arctic.

The work in each region is centered around one main sea ice station, which we aim to visit 3 times during the expedition. During each visit, we will conduct an identical observational programme, while autonomous measurements will be recorded during our temporary absence. This will allow us to study the atmosphere-ice-ocean system during melt season in each ice regime over approximately 6 weeks in July and August 2025. The multi-disciplinary work programme is structured into sea ice physics (Chapter 2), atmospheric sciences (Chapter 3), physical oceanography (Chapter 4) and ecosystem studies (Chapter 5). It furthermore includes a designated communication and outreach programme.

Eis-Ozean-System während der Schmelzzeit in jedem Eisregime über einen Zeitraum von etwa 6 Wochen im Juli und August 2025 zu untersuchen. Das multidisziplinäre Arbeitsprogramm gliedert sich in Meereisphysik (Kapitel 2), atmosphärische Wissenschaften (Kapitel 3), physikalische Ozeanographie (Kapitel 4) und Ökosystemstudien (Kapitel 5). Darüber hinaus umfasst es ein spezielles Programm für Kommunikation und Öffentlichkeitsarbeit.

Die CONTRASTS-Expedition steht in direktem Zusammenhang mit verschiedenen früheren Expeditionen von *Polarstern* im zentralen Arktischen Ozean, insbesondere MOSAiC in 2019/20 (Nicolaus et al., 2022) und ArcWatch-1 in 2023 und ArcWatch-2 in 2024. Unsere Arbeit wird direkt an diese Expeditionen anknüpfen, vor allem durch den zusätzlichen Aspekt des Vergleichs verschiedener Meereisregime. Die Expedition wird von dem etablierten interdisziplinären und internationalen Forschungsteam an Bord und an Land profitieren.

CONTRASTS wird am 2. Juli 2025 in Tromsø, Norwegen, starten und am 1. September 2025 in Longyearbyen, Spitzbergen, enden (Abb. 1). Die Route wird größtenteils durch norwegische (Svalbard) und dänische (Grönland) Gewässer führen. Die genaue geographische Lage der drei Hauptschollen, die die verschiedenen Meereisregime repräsentieren, wird von den Meereisbedingungen im Sommer 2025 abhängen. Wir werden im Frühjahr 2025 damit beginnen, die verschiedenen Meereisregime anhand von Fernerkundungs- und numerischen Modelldaten zu verfolgen. Wir werden dann charakteristische Eisschollen auswählen, die diese Regime repräsentieren, um das Messprogramm durchzuführen. Während des Beobachtungszeitraums werden die Eisschollen driften, so dass die wiederholten Messungen die gleichen Eisschollen besuchen werden, aber an unterschiedlichen Orten. Insgesamt gehen wir davon aus, dass das Expeditionsgebiet der eisbedeckte Arktische Ozean zwischen Grönland, Spitzbergen und dem Nordpol sein wird, der sich höchstwahrscheinlich zwischen 82°N / 10°W und 85°N / 20°E erstreckt.

Es ist geplant, dass die Expedition auch die erste Expedition der neu gebauten französischen Arktis-Forschungsplattform *Tara Polar Station* unterstützen wird, sich beide Schiffe z.B. am 5. Juli 2025 nördlich von Svalbard treffen und dann gemeinsam ins Eis eindringen, wo beide Schiffe dann unabhängig voneinander operieren werden.

Die Messungen und Beobachtungen der *Polarstern*-Expedition CONTRASTS werden durch Luftmessungen der IceBird Summer 2025-Expedition des Polarflugzeugs *Polar 5/6* ergänzt, das von der Station Nord in Grönland aus fliegt. Diese Kampagne wird die CONTRASTS-Eisstationen und Eisregime überfliegen und größere regionale Erhebungen abdecken. Darüber hinaus werden die CONTRASTS-Arbeiten mit der folgenden *Polarstern*-Expedition East Greenland Sources (PS150) verbunden, die darauf abzielt, einige der CONTRASTS-Eisstationen erneut zu besuchen. Beide zusätzlichen Kampagnen werden die CONTRASTS-Beobachtungen räumlich und zeitlich erweitern. Dies wird dazu beitragen, die Skalen zwischen einem verbesserten Prozessverständnis und großräumigen Auswirkungen zu überbrücken. Die CONTRASTS-Expedition wird einen direkten Beitrag zum Helmholtz-Forschungsprogramm „Erde im Wandel – Unsere Zukunft sichern“ in Thema 2, Unterthemen 1, 3 und 4 und Thema 6, Unterthemen 1, 2 und 3 leisten.

The CONTRASTS expedition is directly linked to various previous expeditions of *Polarstern* into the Central Arctic Ocean, in particular MOSAiC in 2019/20 (Nicolaus et al., 2022) and the ArcWatch-1 in 2023 and ArcWatch-2 in 2024. Our work will directly connect to these expeditions, mostly by adding the aspect of comparing different sea ice regimes. The expedition will benefit from the established interdisciplinary and international research team on board and on land.

CONTRASTS will start on 2 July 2025 in Tromsø, Norway and end on 1 September 2025 in Longyearbyen, Svalbard (Fig. 1). The route will mostly lead through Norwegian (Svalbard) and Danish (Greenland) waters. The exact geographic location of the three main floes, representing the different sea ice regimes, will depend on sea ice conditions in summer 2025. We will start tracking different sea ice regimes based on remote sensing and numerical model data in spring 2025. We will then choose characteristic ice floes representing the regimes to realize the measurement programme. During the observational period, the ice floes will drift, such that the repeat measurements will visit the identical ice floes, but at different locations. Overall, we expect the expedition region will be the ice-covered Arctic Ocean between Greenland, Svalbard and the North Pole, most likely stretching between 82°N / 10°W and 85°N / 20°E.

It is planned that the expedition will also support the first expedition of the newly build French Arctic research platform *Tara Polar Station*. Both vessels are planned to meet north of Svalbard e.g. on 5 July 2025 and then steam together into the ice, where both vessels will then operate independently.

The measurements and observations of the *Polarstern* expedition CONTRASTS will be complemented with airborne measurements of the IceBird Summer 2025 expedition of the polar aircraft *Polar 5/6* flying out of Station Nord, Greenland. This campaign will overfly the CONTRASTS ice stations and ice regimes and cover larger regional surveys. In addition, the CONTRASTS work will be connected to the following *Polarstern* expedition East Greenland Sources (PS150), which will aim to revisit some of the CONTRASTS ice stations. Both additional campaigns will extend the CONTRASTS observations in space and time. This will help to bridge scales between improved process understanding and large-scale impacts. The CONTRASTS expedition will directly contribute to the Helmholtz research programme "Changing Earth – Sustaining our Future" in Topic 2, Subtopics 1, 3 and 4 and Topic 6, Subtopics 1, 2 and 3.

2. SEA-ICE PHYSICS

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Objectives

Sea ice acts as an integrator of fluxes and exchange processes between the atmosphere and the ocean and provides a unique habitat that is rapidly changing. The study of sea ice physics is therefore closely linked to all other scientific groups participating in CONTRASTS. Our main goal is to investigate the physical properties and key processes of different sea ice regimes:

- Characterize different sea ice regimes in the central Arctic, which is the focus of CONTRASTS.
- Quantify summer (melt) processes of sea ice as functions of atmospheric and oceanic boundary conditions.
- Advance understanding of ongoing changes in summer sea ice, building on results from previous expeditions (e.g., MOSAiC 2019/2020; Nicolaus et al., 2022).
- Improve knowledge of atmosphere-ice-ocean interactions, with particular emphasis on thermodynamic processes and sea ice's role as both, a habitat and a barrier.
- Enhance observational capabilities, testing new instruments and measurement systems in challenging Arctic conditions.

These objectives are addressed through the following thematic sub-programmes.

Topic 1: Energy Budgets

We aim to quantify how energy is distributed and used for sea ice melt in different regimes over space and time. This focus includes understanding:

- Short-wave radiation (broadband and hyperspectral) and how it is reflected, absorbed, or transmitted.
- Formation and evolution of melt ponds and their contribution to surface, lateral, and bottom ice melt.

- Changes in sea ice surface conditions (e.g., scattering layers, deteriorated ice) and internal ice structure.

These studies will build on insights from previous expeditions (e.g., MOSAiC and ArcWatch-1) and help validate satellite data and improve model parameterizations. A key aspect is linking the mass and energy budgets to understand the fate of meltwater both at the surface (melt ponds) and directly beneath the ice, which can rapidly transition toward refreezing later in the season.

Topic 2: Mass Balance

During CONTRASTS, we will investigate sea ice mass balance, thickness, and snow distribution on various spatial scales and in different ice regimes throughout the summer. The observations (airborne, floe-level, ship-borne) will complement the long-term IceBird survey programme carried out with *Polar5/6* every summer. We are particularly interested in thickness differences among sea ice of varying ages. By combining thickness measurements with satellite-derived ice drift, we can estimate volume fluxes across Fram Strait region.

Topic 3: Remote Sensing of Sea Ice

Hyperspectral Imaging of Melt Ponds and Sea Ice

The colour and spectral signature of melt ponds evolve throughout the melt season, influenced by factors such as pond depth, trapped bubbles, and impurities. Meanwhile, the reflectance of summer sea ice is largely determined by the surface scattering layer. By measuring spectra in the range of 400–1,000 nm, we seek to refine satellite retrievals of surface albedo, melt pond fraction, and possibly melt pond bottom thickness.

Microwave Emission of Sea Ice

Satellite-borne microwave radiometers have monitored Arctic sea ice area since the 1970s. Although many parameters can be retrieved in the freezing season, summer melt (with abundant liquid water on or in the ice) complicates interpretations. We plan to study variability in microwave emission at common satellite frequencies (19, 37, and near 90 GHz), as well as at 1.4 GHz (used for thin ice thickness retrievals) and atmospheric absorption regions (around 23, 56, 183, 243, and 340 GHz). This work aims to improve summer retrieval methods and extend current satellite remote sensing capabilities.

Helicopter-Borne Thermal Infrared Surface Imaging

During summer, temperature differences between ocean, sea ice, and melt ponds often drop below 5 K, but local variations still occur. Helicopter-based thermal infrared imaging will capture this surface temperature variability, helping us to characterize melt pond fractions and the thermal contrast between different ice features and open water.

Topic 4: Bio-Physical Linkages

Cryomineral Detection (WISELIGHT Project)

When sea ice melts or breaks up, cryogenic minerals like gypsum can be released into the upper ocean and potentially transported to great depths (Wollenburg et al., 2020). WISELIGHT will test a novel hyperspectral imaging (HI) technique to detect these minerals in freshly extracted ice cores (800–2,200 nm, SWIR range), filling a critical methodological gap in how we observe and quantify gypsum precipitation in sea ice. The project has three main objectives:

- Develop a method to directly image cryogenic gypsum in sea ice cores using SWIR hyperspectral imaging.
- Obtain a baseline of gypsum content in different ice regimes of the Central Arctic Ocean during the melt season.
- Link optical measurements with ice physicochemical and biophysical properties (temperature, salinity, density, meltwater chemistry, microscopic ice structure).

Additional observations, such as under-ice sediment traps and ROV net sampling, will help determine whether gypsum influences biological material aggregation, sinking rates, and nutrient/carbon fluxes. Complementary measurements of Chl-a, suspended particulate matter, and transparent exopolymer particles (TEP) will also clarify gypsum's ecological role.

Topic 5: Surface Properties of Sea Ice

Snow and ice surfaces become highly heterogeneous during Arctic summer, with melt ponds, leads, ridges, and roughness features all affecting energy and momentum transfer and stability of the boundary layer. Within topic 5 we will focus on the following aspects:

- Quantifying snow/ice surface properties–including albedo, roughness, and melt pond development–influencing the turbulent exchange at the atmosphere-ice interface.
- Assessing near-surface Arctic boundary layer processes caused by surface heterogeneities. We will examine how thermal vs. topographic drivers influence local wind systems and turbulent energy exchange.
- Improving model parameterizations of small-scale boundary layer processes in climate models.

A key component is understanding the ice-albedo feedback. We will integrate airborne (e.g., drones, helicopters, airplanes) and ground-based observations to map melt pond fraction, bathymetry, sea-ice thickness, and surface albedo in multiple ice regimes. Ground data will validate bathymetry measurements from airborne sensors (including a scanner with a green laser on aircraft *Polar 6*). We will also evaluate the utility of drones as a complement or alternative to helicopters for broad-scale melt pond observations under various weather conditions.

Topic 6: Operations in Ice-Covered Waters

We are conducting a project called IceWise to evaluate the added value of using satellite data for navigation in ice-covered waters. To number the added value, we will compare transits made through ice with and without satellite-support (MapViewer). During transit, following parameters will be monitored:

- Engine parameters (fuel consumption, engine load)
- Progress through ice (speed, route efficiency)
- Time saved (overall transit duration)
- Ice type (ice thickness using the SIMs and optical data from Panomax)

By analyzing operational metrics under these different navigation strategies, we aim to quantify the benefits of state-of the art satellite data (Sentinel-1, TerraSAR-X, RADARSAT) integration for more efficient passage through different ice types and regimes.

Topic 7: Sea Ice Dynamics

Finally, we will investigate sea ice dynamics using a network of GPS-equipped buoys deployed in Fram Strait and further north. This region experiences heavy deformation and dynamic thickening, and satellite-derived motion or deformation parameters can be unreliable. The buoy network will:

- Provide high-resolution drift data
- Capture deformation events across spatial scales
- Improve understanding of how ice in this region evolves under strong dynamic forcing

These insights will be especially valuable for refining satellite-based motion and deformation products in areas where existing methods face large uncertainties.

Work at sea

The field activities planned for CONTRASTS can be grouped into six main tasks. Work will be similar across the three designated sea-ice regions. Most activities occur directly on the ice while the vessel is stationary (ice stations of up to 72 hours), supplemented by helicopter and drone surveys around the ship. Routine observations and continuous remote-sensing measurements will also run along the transits between stations.

Task 1: Surface Measurements during Ice Stations

We will conduct on-ice measurements aimed at quantifying sea ice, snow, and melt pond properties, as well as their distribution. These measurements will cover all relevant ice types and surface features present at each station.

A. Surface Albedo Measurements

- Using hyperspectral (ASD) radiometers and broadband (Kipp & Zonen pyranometer) instruments.

B. Under-Ice Meltwater and Pond Surveys

- Drill transects to capture thermohaline properties in the upper ~5 m of the ocean.
- Observing melt ponds to link meltwater sources, sinks, and pathways.

C. Repeat Measurements of Surface Scattering Layer (SSL)

- Tracking SSL evolution (e.g., at a floe that will be revisited later in the cruise) to observe changes during freeze-up.

D. Thickness and Snow Depth Transects

- Sea Ice Thickness: GEM-2 electromagnetic sensors.
- Snow Depth: MagnaProbe measurements.

E. Snow/Ice Surface Properties (HOtIce project)

- Following MOSAiC-type protocols to measure snow and ice characteristics (temperature, salinity, density, stratigraphy) at multiple spatial scales (microscale to ~200×200 m). These data support broader collaborative research within CONTRASTS.

F. Hyperspectral Imaging of Melt Ponds and Sea Ice (Specim IQ, 400–1,000 nm)

- Nadir Measurements: Using a tripod at 2–4 m height to capture single melt ponds, with additional pond-bottom thickness checks via GEM-2 and drillings.
- Transect Measurements: Along the same lines used for thickness and snow depth measurements (intervals ~5–50 m). A white reference plate is placed in view for calibration.

G. Microwave Emission (L-Band) Along Transects

- A portable MWSE "ARIEL" radiometer (1.4 GHz) will be mounted on a sledge and pulled along transect lines. Incidence angles (30°–60°) will be tested at each stop.
- Concurrently, cores and snow/SSL samples (temperature, salinity, density, grain size, roughness, permittivity) will be collected to interpret the radiometer data.

H. In-Situ Melt Pond Depths

- Measured with GEM, MagnaProbe, hand-held acoustics, single-beam approaches, and SPLISH (Surface Pond Level Information Sensing Hardware).
- Salinity recorded at each site.
- A tachymeter (using free stationing toward local GNSS stations) ensures accurate repeat positioning for follow-up measurements.

Task 2: Airborne Measurements

A. Drone Surveys (DJI Mavic 3, Matrice350)

- Drone-based photo surveys will be conducted at each station floe to map sea ice surface conditions. Images will be stitched for:
- High-resolution surface classification (including melt ponds)
- Surface elevation models (digital elevation maps)

B. Helicopter-Based Sea Ice Thickness (EM-Bird)

- We will operate the AWI EM-Bird by helicopter along the cruise track through sea ice. This provides thickness distribution functions on scales of <60 nm around the ship. The data will also help develop and refine the system under various ice conditions.

C. Helicopter-Borne Thermal Infrared (TIR) Imaging

- A nadir-looking Infratec Vario-CAM HD head 680 TIR camera will be part of the helicopter's sensor suite to measure surface temperature variability among sea ice, melt ponds, and open water. These data can reveal small-scale thermal contrasts even when overall temperature differences are relatively low in summer.

D. Airborne Acquisition of Sea Ice and Melt Pond Characteristics

- A nadir looking NIKON camera together with a RIEGL Lasercanner mounted on board the helicopter will provide additional optical data for classification and laser records for the construction of digital elevation models at larger scales. Those measurements complement drone surveys and provide an overview of ice conditions at a larger scale.

Task 3: Sea Ice, Melt Pond, and Snow Sampling

We will collect physical property data from sea ice, melt ponds, and snow, in close coordination with ecological and biogeochemical sampling and under-ice water samples.

A. Ice Coring, Melt Pond Water, and Snow Sampling

- Physical analyses (temperature, salinity, density, stratigraphy, oxygen isotopes)
- Ice core scanning for biophysical properties (e.g., Chl-a, porosity, brine channels)

B. Cryomineral Detection and Bio-Physical Linkages

- At each station, a 50 m transect near the ROV survey grid will be established. Triplicate ice cores taken every 10 m (15 total per station).
- Each core section is immediately scanned with a VNIR-SWIR hyperspectral system (Cimoli et al., 2020) for detecting gypsum and biological markers.
- Core temperature, salinity, and density measurements will explore the link between gypsum precipitation and optical properties.
- Hyperspectral data will be validated with conventional crystal-quantification methods (in collaboration with the ECO team).

Task 4: Remotely Operated Vehicle (ROV) Operations

We will operate the AWI ROV system “Beast” with its interdisciplinary sensor suite. The ROV is deployed via a hole in the sea ice and can move within a radius of ~300 m, accessing different ice types within each station’s floe.

Main dive missions include:

- Horizontal (2 m depth) and vertical (down to ~100 m) surveys of under-ice light conditions (radiance and irradiance).
- Mapping microscale under-ice habitat patterns using Underwater Hyperspectral Imagery (UHI, Ecotone system).
- Sea ice draft (thickness) measurements via multi-beam sonar.
- Visual mapping of the ice underside, including video documentation of installed instruments.
- Collection of bio-physical water properties (e.g., CTD-type profiles).
- Towing of small plankton nets.
- Coordination with Cryomineral Detection: Sampling transects (for ice coring) will be co-located near ROV grids to link under-ice hyperspectral data with ice core analyses.

Task 5: Autonomous Measurements / Seasonal Installations

A central element of CONTRASTS is continuous observation of sea ice processes on three main ice floes. We will deploy multiple autonomous stations (buoys) of varying complexity. Additional, simpler stations may be installed along the cruise track or by helicopter in each region. Some systems will be recovered at the end of CONTRASTS, whereas others will continue drifting and transmitting data until they fail, extending observations beyond the expedition timeframe. Collaboration with PS150 EGC-Sources may allow further buoy deployments and revisits.

Examples of planned autonomous stations:

A. Remotely Operated Vehicles (operated from Bremerhaven) capturing visual surveys and under-ice PAR.

B. Snow Buoys measuring snow accumulation and basic meteorology.

C. Sea Ice Mass Balance Buoys (type SIMBA) measuring temperature profiles (air/snow/ice/water), effective latent heat, and ice thickness.

D. Seasonal Ice Mass Balance (Version 3, SIMB3) Buoys, one equipped with a Snow Thickness and Temperature Observation System (SnowTATOS) for remote snow monitoring in addition to standard SIMB3 data.

E. Radiation Stations measuring hyperspectral irradiance above and below the ice.

F. Time-Lapse Cameras documenting surface and under-ice conditions (including ablation stakes).

G. Autonomous Weather Stations measuring standard meteorological parameters (air temperature, pressure, wind speed/direction, humidity, shortwave and longwave radiation).

H. Surface Velocity Profilers (SVP) measuring barometric pressure and partial surface temperature.

I. Ground-Based Network of Georeferenced Target Points (GNSS Stations)

Task 6: *On-Board* Measurements

A. Panorama Cameras (Panomax)

- Two panoramic cameras installed above the crow's nest will capture photographs or short videos (e.g., every 10 minutes).
- Some images may be transmitted in near-real time to a project website for outreach and public engagement.

B. Bridge-Based Sea Ice Observations

- Standardized observations from the bridge, recording sea ice concentration, floe size, ridging, thickness, plus weather conditions and large fauna, within a ~1.5 nm radius.

C. Ship-Based Microwave Radiometers

- Instruments mounted on the "Peildeck" can measure both upward-looking atmospheric emission and downward-looking surface emission (frequencies: 1.4, 23, 56, 183, 243, 340 GHz).
- During ice stations, we will perform *in-situ* measurements (e.g., core sampling, SSL property checks) within the radiometer footprints to validate and model microwave emission data.

D. Ship-Based electromagnetic ice thickness (SIMS)

- Using a electromagnetic ice thickness sounder installed in front of the bow, we will monitor ice thickness along ship track. Data is used to number engine/ship performance under different ice conditions

Expected results

We anticipate that our mass balance studies – encompassing airborne, on-ice, and buoy-based observations – will contribute significantly to the long-term record of sea-ice thickness changes in the Central Arctic. In particular, we will compare observations from this expedition with previous efforts (e.g., MOSAiC drift, IceBird campaigns, and IABP data), providing fresh insights into the rapid thinning of sea ice along the Transpolar Drift and within different ice regimes. The combination of new technology, such as SnowTATOS and various snow-depth sensors, will refine our capacity to track spatial and temporal variations in snow cover. This information is crucial not only for sea-ice mass balance but also for under-ice meltwater processes, which influence biogeochemical fluxes and ecological communities but remain poorly understood.

A major focus will be on surface topography, where drone-based surveys will produce high-resolution digital elevation maps (DEMs). If sufficient precision is achieved, difference maps over time will reveal subtle rates of surface ablation. Parallel ROV observations from beneath the ice will enable us to map ice drafts and potential bottom ablation, and combining top- and bottom-based DEMs will offer novel three-dimensional reconstructions of floe evolution. For melt pond characterization, we plan to collect linear profiles of pond depth (with centimeter-level trajectory accuracy), measure pond salinity, and generate 3D pond geometries from airborne data validation obtained during the IceBird programme (taking place in parallel). Moreover, these data will refine existing melt pond classification algorithms (e.g., PASTA) by integrating near-infrared imagery and salinity profiles.

In parallel, a core objective is to elucidate energy budgets across the transition from melt to freeze-up. Our surface albedo surveys, merged with high-resolution drone imagery, will allow the creation of albedo maps under varying ice conditions. These data feed into broader energy partitioning assessments, particularly when paired with under-ice radiation mapping by ROV. By capturing transmitted shortwave radiation beneath different snow and ice types, we can build a more complete 3D picture of energy fluxes–encompassing leads, ridges, thin/new ice, and melt ponds. Such observations will help fill gaps left by the MOSAiC expedition regarding late-summer and autumn transitions and should advance our grasp of how heat and light move through the upper ocean-ice-atmosphere system.

From a bio-physical perspective, the first field-based SWIR hyperspectral approach for detecting cryogenic minerals (e.g., gypsum) in Arctic sea ice will shed light on previously understudied processes. By capturing temperature, salinity, and growth conditions alongside high-resolution scans of ice cores, we hope to reveal the environmental factors that drive gypsum precipitation. Integrating these findings into biogeochemical and ecosystem models will clarify how cryominerals influence biological communities, carbon cycling, and overall sea-ice dynamics. Complementary ice texture, biomass, and biogeochemical datasets will further strengthen collaborative links among researchers on this expedition, providing a system-wide view of Arctic sea-ice processes.

Additionally, hyperspectral imaging of melt ponds and sea ice in the 400–1,000 nm range will enable us to track spectral and structural changes in pond bottoms over the course of the expedition. Such measurements will refine satellite retrievals for surface albedo, melt pond fraction, and ice properties, especially when paired with microwave emission observations. By modeling snow and ice brightness temperatures (using SMRT and PAMTRA) and comparing them against our ground-truth radiometer data, we aim to identify key parameters influencing microwave emission and to adapt those insights for satellite-based retrievals at similar frequencies. Helicopter-borne thermal infrared imaging, meanwhile, will complement these efforts by distinguishing areas of open water, ice, and melt ponds and then classifying them via machine-learning approaches (Reil et al., 2024). Joint analysis of TIR brightness temperatures and visible imagery will help validate classification algorithms across a range of summer ice conditions.

Within the HOtIce framework, detailed measurements of snow and ice surface roughness, liquid water content, and evolving melt features will refine our understanding of how near-surface atmospheric processes change over heterogeneous summer sea ice. By linking these surface parameters to boundary-layer wind and temperature data (including detailed measurements around ridges, pond edges, and leads), we will quantify how local topographical breaks influence heat and momentum exchange. These results align with simultaneous atmospheric observations, illuminating the horizontal advection of sensible and latent heat across differently aged and textured ice surfaces. Ultimately, we expect this synergy of sea-ice and atmospheric measurements to enhance climate model parameterizations and our ability to predict Arctic sea-ice evolution under continued warming.

Finally, the melt pond surveys will benefit from precise *in-situ* depth measurements, orthomosaic mapping of observation areas, and repeated DEMs of the floe to capture temporal changes in elevation and surface melt. Evaluating the accuracy of diverse measurement platforms (optical cameras, green lasers, etc.) and combining data from multiple airborne platforms will further refine our capacity to observe and classify melt ponds at the floe and regional scales. Taken together, these results will yield a holistic picture of Arctic sea-ice processes, bridging knowledge gaps in mass balance, energy fluxes, ecological connections, and operational efficiency in the ice-covered ocean.

Alongside these ice-centric objectives, we also expect improved ship efficiency in ice-covered waters through the strategic use of satellite data, particularly Sentinel-1 and TerraSAR-X. Automated tools such as EDEN (a platform that corrects image displacement directly on board) should enhance real-time ice navigation, reduce travel times, and optimize fuel use. By comparing engine parameters, transit speed, and overall time saved while using or not using satellite-guided routes, we aim to demonstrate how advanced remote sensing can streamline polar operations.

Data management

All environmental data obtained during this expedition will be archived, published, and disseminated according to international standards by the World Data Center PANGAEA (Data Publisher for Earth & Environmental Science; https://www.pangaea.de) within two years after the end of the expedition at the latest. Unless specified otherwise, a CC-BY license will apply. Measurements from autonomous systems, which transmit data in near real time via satellite communication, will be made immediately available through the data and information portal meereisportal.de. Any other data will be submitted to an appropriate long-term archive that provides unique and stable identifiers for the datasets and allows open online access to the data.

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3. ATMOSPHERIC SCIENCES

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Objectives

The atmospheric programme for CONTRASTS is very much focused on the direct interactions between the atmosphere and the variable surfaces in the central Arctic. With that perspective in mind, the research is organized around three basic scientific objectives.1) Quantify the atmosphere-surface exchanges that impact the sea ice energy and mass budgets, the upper ocean mixed-layer heat budget, and other key bio-physical processes in the ocean-ice system. To achieve this objective requires atmospheric observations that are coincident with related sea ice and ocean observations. Those atmospheric observations will quantify all components of the surface energy and momentum budgets, including the surface skin temperature and fluxes of radiation, turbulent sensible and latent heat, and momentum. 2) Understand the drivers of variability in atmosphere-surface exchange processes and how these might be sensitive to the underlying ice and ocean properties. Variability in surface exchange processes can be driven by advection in the atmosphere, structural changes in the atmospheric boundary layer, the development and phase of clouds, precipitation in the atmosphere and reaching the surface, and the vertical structure of atmospheric winds and turbulence. To develop a process-based understanding of surface exchange requires coordinated measurements of these processes along with the resultant surface fluxes. 3) Develop process-based model diagnostics from the observations at the three primary sites and their associated spatio-temporal variability. To support model predictive capabilities in the Arctic, and particularly of the changing sea ice and atmosphere-surface interactions, requires robust model representations of the essential processes responsible for controlling variability in surface heat and momentum. For example, the relationship between the net radiation at the surface and the sensible heat flux represents a key balance that interacts with heat conduction through the sea ice to determine the surface skin temperature (e.g., Solomon et al. 2023). To achieve the appropriate partitioning of energy in the delicate sea ice system, models must represent the balances at play. Diagnostics built from the observations in disparate sea ice conditions will be important for assessing model performance under a range of realistic and representative conditions.

Work at sea

Atmospheric observations will be made through a combination of measurement systems that are installed onboard *Polarstern* and onboard vehicles, and those that will be deployed on the sea ice both at the three contrasting ice nodes and during ice stations, when logistics allow. Each of the contrasting ice nodes will have an Atmospheric Surface Flux Station

(ASFS), similar to those deployed at remote sites during MOSAiC. These measure all terms of the atmospheric surface energy budget, including: upward and downward, shortwave and longwave radiative fluxes using broadband, hemispheric radiometers; turbulent sensible and latent heat fluxes as well as momentum flux using sonic anemometer; surface meteorology using a standard met package; and skin temperature derived radiometrically. These stations run autonomously and are powered by methanol fuel cells that can last for approximately 2.5 months until refueling is needed. Limited data can be transferred in quasi-real time via satellite transmission. During the ice stations there will be accompanying mobile and quasi-stationary measurements near *Polarstern*. These will include a 10-m tower with standard meteorological observations at several heights to gain insight into the lowermost structure of the atmospheric boundary layer that aids in the interpretation of, for example, sensible heat flux processes. Measurements of turbulent sensible and latent heat fluxes close to the surface at different locations will enable to quantify the effect of surface heterogeneity caused by melt pond or leads on the near-surface atmospheric layer. Moreover, a setup utilizing a thermal infrared camera pointing at thin, vertically mounted screens visualizes air temperature dynamics over the heterogenous surface. Additionally, meteorological and radiation measurements made from Unmanned Aerial Vehicle (UAV) profiles and transects will provide further insight into the spatio-temporal distribution of surface features (melt ponds, scattering ice, leads, ridges), their surface albedo and temperature, and the thermodynamic structure of the ABL. The UAV-based surface albedo mapping will be carried out on the same sea-ice area where the under-ice ROV will measure the downwelling shortwave radiation, to enable the calculation of the shortwave transmittance/absorptance through the ice. The extent to which the UAVs can be operated at each of the contrasting ice regime sites will be explored at the site, and may be subject to given local conditions and operational constraints. Some important atmospheric measurements are made using highly sophisticated, and sometimes power intensive, instruments that do not lend themselves to autonomous, remote operation. Nonetheless, these measurements are exceedingly important for understanding the fundamental atmospheric processes that drive the primary modes of variability in the surface energy and momentum budgets. Thus, a subset of observations will be made by remote-sensing and *in-situ* instruments installed onboard *Polarstern*. These types of systems have all been operated from *Polarstern* in the past, such that their installation and operation is feasible. To characterize the atmospheric structure, a 6-hourly radiosonde program will be implemented to provide a backbone of high vertical resolution measurements of atmospheric temperature, moisture, and winds extending from the deck of *Polarstern* up to the lower stratosphere. A set of microwave radiometers covering the 22 to 340 GHz frequency range will be operated to complement the sounding programme. A Doppler lidar will be operated to provide continuous information on the wind profile in the lowest atmosphere. Clouds and precipitation are also major controls on the surface energy and mass budgets. A G-band differential absorption radar will be able to detect small cloud hydrometeors, while its dual-frequency measurements near the water absorption line at 183 GHz allow for vertical profiling of water vapor. The addition of a W-band cloud radar sampling the same air volume, will enable us to identify cloud regions consisting of smaller particles, corresponding to supercooled liquid droplets. The W-band radar includes a passive channel, that will further help to characterize the cloud liquid water path. These observations will be complemented by total sky cameras in the visual and infrared spectral range. Precipitation will be measured by a laser disdrometer which assesses the amount of precipitation reaching the ship and also classifies it into precipitation types. An ultrasonic anemometer for wind measurements will correct for precipitation misclassification. An onboard ceilometer will provide an additional constraint on the vertical height of clouds. Combined with the microwave radiometer measurements, this cloud information will help to constrain cloud phase and radiative impacts. Lastly, the *Polarstern* met measurements provide continuous, high-temporal resolution measurements of the near-surface atmospheric state. Collectively this instrument suite provides information on the evolution of the atmosphere that is essential for many analyses and model studies. Lastly, a basic set of radiometers will be installed onboard *Polarstern* to measure the downwelling longwave and shortwave broadband radiation, similar to the measurements that will be made at the ASFS installed at the different sea ice nodes. These measurements will be complemented by downward facing surface cameras in the visual and infrared range, covering the same area as the radiometers. The surface skin temperature near *Polarstern* will be derived using a downward pointing infrared thermometer. While not all components of the surface energy budget can reliably be measured from *Polarstern*, this basic set of measurements will help to link the other measurements made onboard with those made continuously at the sea ice nodes. The atmospheric work plan will include routine launching of weather balloons, daily maintenance of all onboard instruments, preparation and installation of all instrumentation at the sea ice nodes, operation of on-ice instrumentation during periodic ice stations (when time allows), and routine monitoring and quality control of data.

Expected results

With the measurement setup and activities outlined above, we will be able to collect data for answering the pressing questions that surround our three objectives. Measurements of the surface energy budget terms, combined with adjacent measurements of the snow-, sea ice, and upper ocean properties, will provide the baseline to quantify the processes in the coupled ocean-ice-snow-atmosphere system. A particular focus here is the role of individual processes as drivers for – or responses to – this changing system during the melting season, and to what degree they depend on the surface characteristics. Due to the design of CONTRASTS, these processes and their relationships can be studied at three different ice regime sites simultaneously.

The vast measurement suite both on the ice and on the ship, covering vertical thermodynamic structure, cloud and water vapor properties and surface energy fluxes, will allow detailed characterization of drivers of sea ice surface- and atmospheric variability. Throughout the course of CONTRASTS, each of the ice stations and the ship will be under the impact of continuous synoptic variability, such as intermittent cyclone passages, warm/cold intrusions, or high-pressure blocking conditions. Such phenomena provide a major part of forcing for the combined ocean-ice-snow-atmosphere system in the melting season, and with CONTRASTS, we can measure their impacts, as well as their spatial gradients and dependence on the ice regime, in detail.

Finally, the combined data will be used to investigate process-relationships, such as the intricate relation between radiative forcing, near surface stability at the surface and turbulent heat fluxes, or relations between cloud properties, long- and shortwave radiative fluxes, and surface properties. The UAV-based mapping of surface albedo combined with under-ice radiation observations will also enable the study of the in-ice and under-ice physical and biogeochemical processes driven by the penetration of solar radiation. Furthermore, the dataset helps to disentangle the complex interactions of the near-surface atmospheric dynamics and (sub) meter-scale surface heterogeneities. Such process-based diagnostics will be used to evaluate process representation in models, and especially the site-to-site variability, will be essential to understand variability in key relationships and processes. Collectively, these datasets and diagnostics will contribute to improved parameterizations of those processes in models.

Data management

Environmental data will be archived, published and disseminated according to international standards by the World Data Center PANGAEA Data Publisher for Earth & Environmental Science (https://www.pangaea.de) within two years after the end of the expedition at the latest. By default, the CC-BY license will be applied.

Molecular data (DNA and RNA data) will be archived, published and disseminated within one of the repositories of the International Nucleotide Sequence Data Collaboration (INSDC, www.insdc.org) comprising of EMBL-EBI/ENA, GenBank and DDBJ).

Any other data will be submitted to an appropriate long-term archive that provides unique and stable identifiers for the datasets and allows open online access to the data.

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4. PHYSICAL OCEANOGRAPHY

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Objectives

The main objectives of the ocean physics work are both (1) extensive meso-scale surveys, including autonomous instrumentation and helicopter-assisted manual surveys, around each planned ice station, and local (2) measurements of turbulence in the water column and right under the sea ice to estimate mass, heat and momentum fluxes; as well as processes associated with leads and the ice floe edge. Studying the strong links of ocean physical processes to the ecosystem and biogeochemistry will be facilitated by this multidisciplinary expedition.

CONTRASTS will enable quantification of the distribution and evolution of thin meltwater layers (under ice and in leads) under different sea ice regimes. The expedition will enable us to capture the temporal evolution and dissolution of these layers. Spatially, to capture the conditions that permit meltwater layers to persist into freeze-up, and the role that they play in pre-conditioning new ice formation. The side proposal LEAD will investigate the spatial impact of a lead in ocean dynamics and in primary production under the sea ice.

At each site, repeated measurements will allow us to connect the solar heating (quantified during the first visit) to the upper ocean thermohaline structure and resulting bottom and lateral melt rates (quantified during the second visit). Coordination with other teams will enable understanding of the impact of thin meltwater layers and false bottoms on coupled system processing including productivity and biogenic air-sea gas exchange. In particular, measurements in different sea ice regimes with widely varying sea ice thicknesses, optical conditions, and nutrient loads will allow us during CONTRASTS to address the outstanding question of how upper ocean optics in thin meltwater layers impact productivity rates.

Work at sea

The physical oceanography work will entail deep CTD/rosette (CTD: Conductivity Temperature Depth) casts to the sea floor, measuring a multitude of variables across depths / pressures, such as temperature, salinity, dissolved oxygen, fluorescence of Coloured Dissolved Organic Matter (CDOM) and Chl-a, inorganic nitrate and optical transmission (particles). The CTD/rosette will allow sampling by various groups on-board.

Local observations from the ice station floes will make use of more mobile platforms, including time series of turbulent microstructure (MSS) together with various other sensors (CTD, dissolved oxygen, Chl-a fluorescence), parallel nitrate profiling (SUNA), under-ice turbulent fluxes (eddy covariance, high-frequency acoustic doppler devices) and continuous acoustic velocity observations (ADCP from ship and under-ice). All the mobile water-column devices will be run from the ice (ice hole, ice edge / lead) as well as in leads (zodiac, powered or unpowered on tether, pontoon platforms).

Parallel to on-ice-station work, areal surveys using the helicopter will include all of the above mobile devices and, additionally, buoy deployments and a network (with a resolution of <10 km) of expendable CTDs (xCTDs) around the ice stations, to capture the (sub-)mesoscale ocean around the ice station. Buoys include ocean profilers (e.g., IAOOS) and fixed-depth, frequently measuring CTD (Salinity Ice Tether, SIT). In cooperation with the sea ice group, various upper-ocean and under-ice measurements will be carried out; in particular, buoy-based radiation and water temperature. SIMB-C buoys deployed at each site with additional upper-ocean conductivity cells will capture the upper ocean thermohaline evolution, including changes in thin meltwater layers. Simple wave buoys utilizing a combination GPS and IMU unit will be deployed at each site to capture directional wave spectra in the event of a notable wave event. This will be especially important for interpreting the evolution of the thermohaline structure in the time between ice stations.

To analyze mesoscale (2–10 km) variability, we plan to deploy 3 PSIT (CTD chain) buoy systems around each sea ice floe, forming three small distributed networks, analogous to MOSAiC (e.g. Rabe et al., 2024). For calibration and validation, we will conduct CTD profiles using a fishing-rod CTD during both deployment and/or recovery to ensure data accuracy.

Also, high-resolution acoustic Doppler current profilers (ADCPs) will be deployed beneath one of the three ice floes at four distinct locations within the flow: in front of and behind the ridge, within the marginal ice zone, and in the inner portion of the marginal ice zone. This deployment aims to evaluate mixing processes by quantifying how environmental conditions influence Reynolds stress, shear production, and the dissipation rate of turbulent kinetic energy (TKE). The study will also reference prior research to ensure methodological consistency (e.g., Reifenberg et al., 2025).

Turbulent heat flux at the ice-ocean boundary layer (IOBL) will be measured using the eddy covariance system (ECS) (Kawaguchi et al; 2022; 2024). The synchronized system measures heat, dissolved oxygen (DO) and current velocity at high frequency so that it can detect turbulent-related processes. It enables to measure the oceanic heat and oxygen flux underneath the sea ice. In the meantime, the IOBL observation will be autonomously implemented with the CrioTeC buoys that are equipped with temperature-conductivity and velocity sensors. We will utilize the technique that is applied in previous study (Son et al., 2022) for analyzing the freely drift ice-mounted buoy data.

Continuous ADCP measurements in combination with continuous CTD (buoy) operation will enable the measurement of internal waves and ambient thermohaline field. During transit, measurements of CTD profiles will make use of underway (expendable CTD, “XCTD”) and helicopter-assisted (fishing-rod CTD, XCTD) water column profiling. Further, the shipboard thermosalinograph will allow to resolve horizontal gradients in the upper ocean mixed layer.

Meltwater survey lines will be identified at each site to quantify (1) the extent of thin meltwater features and (2) the character of meltwater layers and their oceanographic impact. Meltwater transects under the ice will use 5-cm drill holes through which a YSI proDSS will be deployed to measure temperature, salinity, turbidity, and dissolved oxygen. This approach builds on the sampling methods used during MOSAiC (e.g., Smith et al., 2022a) and have been deployed during the ArcWatch 1 campaign. Additionally, spectral irradiance measurements will be made through holes to characterize the under-ice light field and solar heating. By combining these measurements with above-ice spectral irradiance measurements, the spectral with above-ice spectral irradiance measurements, the spectral transmittance of different ice types will be estimated- Estimates of the spectral transmittance of the sea ice cover will enable us to estimate the under-ice light field and solar heating between direct measurements.

To study the spatial impact of a lead on ocean dynamics, a survey line will be maintained from the lead to the central floe (main coring site). This survey line will be monitored with ROV survey (blueye), microstructure measurement (MSS), nitrate and DO sensors. The surface of the lead will be investigated using an USV. Sea ice stakes will also be placed adjacent to the ice edges to characterize lateral melt rates between visits.

Expected results

We expect to have preliminary observations of temperature, salinity and horizontal current velocity to resolve the mesoscale quasi-synoptic state of the upper ocean around each ice floe. Further, we plan to obtain observations of the ocean state and dynamics at much smaller scales, covering the interior of an ice floe, the edge and the adjacent lead. This includes vertical turbulent fluxes of nutrients, salt, heat and momentum just under the ice and in the upper water column, as well as meltwater layers and biogeochemical / biophysical processes close to the surface. All of the above will be obtained for different ice (and ocean) environments, allowing an exemplary comparison of these specific cases…In addition, the observations will contribute to large-scale observing of the upper Eurasian Basin.

Below are more detailed expected results of the different components of the programme.

A detailed 3-dimensional (20 km x 20 km x 1,000 m) thermohaline filed is expected by the deployment of the XCTD network around the ice station. After the two repeated visits at each ice stations, gradients in the temporal and spatial domains can be better evaluated. In making use of the concurrent ship-based and buoy-based ADCP current measurements, dynamics controlling the observed thermohaline variability at these different ice regimes can be also explained.

Using high-resolution ADCP data and the distributed SIT buoy systems, we expect to gain a deeper understanding of not only variations in under-ice turbulence under different environmental conditions but also enhance our knowledge of upper ocean mixing and changes in heat flux/budget beneath sea ice during boreal summer. By using the ECS, the heat content variation during melting season depending on the ice condition will be increasingly understood. The accompanied autonomous ice-buoy observation by the CrioTec will give a vision to figure out the upper ocean variation not only the ice-ocean exchange of heat but also that of kinetic energy. The timeseries data from IOBL salinity measurement will let us do more accurate estimate of the thermodynamical impact due to under-ice turbulence, especially in the context of the sea ice basal melting.

Upper ocean observations will provide the key pieces for revealing the co-evolution and interactions between meltwater layers, solar heating, and bottom and lateral ice melt. The sea ice mass budget and solar transmittance measurements allow quantification of fresh meltwater volume and solar radiation into leads and the surface ocean immediately beneath the sea ice. Combining these observations with atmospheric and sea ice properties will enable quantification of the drivers and variability of near-surface stratification, partitioning of heat in the upper ocean, and subsequent impacts on sea ice mass and energy budgets across the three sea ice regimes. We expect the inputs of meltwater to shift from bottom- to top-melt dominated as we move from marginal ice zone to the Last Ice Area (e.g., Perovich et al., 2015), which would result in impacts on solar heat distribution and bottom and lateral ice melt.

We will test hypotheses that the presence of meltwater layers beneath the ice stalls bottom melt across regimes and that under-ice meltwater layers are spatially concentrated due to ice morphological features (e.g., ridges; Smith et al., 2022a; Salganik et al., 2023). This will be done in combination with under-ice topography and ocean property ROV observations. We expect greater drift speeds and small waves in the marginal ice zone will prevent the formation of thin meltwater layers underneath the ice and in leads, impacting lateral melt rates (e.g., Richter-Menge 2001; Smith et al., 2018).

The different measurements around the lead will allow us to map physically the ocean component of a lead, and its evolution over the summer. With some upscaling of the data using satellite products, we will be able to understand the contribution of leads for the primary production in the Arctic.

Data management

All data will be delivered to the data base PANGAEA – Publishing Network for Geoscientific & Environmental Data at the World Data Center for Marine Environmental Sciences (WDC-MARE) (www.pangaea.de) or the Arctic Data Center (https://arcticdata.io). This guarantees long term storage and open access availably. The time frame of delivery will depend on the data processing, sample analysis and quality assessment which depends largely on the various methods. All data will be available to the public latest 2 years after their final processing. In-situ electronically measured data, e.g., CTD or weather station data, will be available to the public after 6 months. Most of the ice buoys will be available in near-real time through the online portal meereisportal.de, and will be embedded into different international data bases. Some units will report data directly into the Global Telecommunication System (GTS), such that their data may be immediately used for weather forecast and ice services. From the ice station work, collected ice cores and snow samples will be partly melted and analyzed on board. The other ice samples will be stored frozen for later analysis in the home laboratories and replicates will be archived and stored at AWI in Bremerhaven. DNA data will be deposited in NCBI's Sequence Read Archive. Meta data and station books are recorded on board through the DSHIP and SENSOR systems. This allows direct linkage of all data to sensor meta data. Since this system focusses on on-vessel stations, the system will be extended to the ice floes, enabling complete documentation of all samples and data recording during ice stations, incl. their relative locations. We do not expect legal conflicts with any of the data and samples. Data ownership and curation responsibilities are with the principal investigator of the respective instrument / method and is defined in the SENSOR system.

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5. ECOLOGY AND BIOGEOCHEMISTRY

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Grant-No. AWI_PS149_04

Outline

The rapidly changing climate is driving unprecedented transformations in the Central Arctic Ocean (CAO). The decline in sea ice coverage, at a rate of approximately 13% per decade relative to the mean September extent for 1981–2010 (Serreze and Meier 2019), along with increasing temperatures and reduced ice thickness (Kwok 2018), is reshaping Arctic ecosystems. These changes influence primary production (Wassmann and Reigstad 2011) and have major implications for the food web, pelagic-benthic coupling, and biogeochemical cycles (Wiedmann et al. 2020). However, the complex interplay of environmental drivers, combined with the logistical challenges of accessing the Arctic, makes predicting future ecosystem shifts and carbon fluxes difficult. During the CONTRASTS expedition, we will investigate the effects of distinct sea-ice regimes on productivity, carbon export, biodiversity, ecosystem structure, trophic interactions, remineralization, and carbon sequestration. Our findings will contribute to a better understanding of the ongoing transformations in the CAO.

Objectives

The overarching aim of the Ecology and Biogeochemistry Team on the CONTRASTS expedition is to analyze the distribution of organisms, biodiversity, and ecosystem functions in relation to environmental drivers in the changing Arctic physical-chemical-biological system. CONTRASTS provides an opportunity to conduct process studies in three distinct sea-ice regimes and compares the results to previous Arctic expeditions, including IceArc II (ArcWatch-1) and TransArc II (ArcWatch-2). Given the challenges of studying long-term changes in the biological system in the remote CAO, we will integrate autonomous systems and sampling techniques to collect biological data over extended time periods without human interference. Specifically, we aim to:

- Compare the taxonomic composition, functional community structure, and biodiversity in the contrasting sea-ice regimes in relation to environmental drivers, including key physical and biogeochemical properties of sea ice, the ice-water interface, melt ponds, and melt-water layers.
- Identify potential geographic sources (Pacific vs. Atlantic) of phytoplankton and zooplankton taxa, which act as potential seed areas for the influx of new species into the Arctic and adjoining seas.

- Quantify and compare key ecosystem functions and biogeochemical processes, including primary production, secondary production of prokaryotes and eukaryotes, trophic carbon flux, vertical carbon export, and the production of climate gases such as methane and dimethyl sulfide (DMS).
- Assess the functioning of the biological carbon pump across different ice regimes to understand how ice conditions and cryogenic mineral content influence its efficiency.
- Compare the trophic connections between sea ice and the mesopelagic realm in the three regimes, with an emphasis on the role of pycnoclines, frontal structures, and eddies.
- Investigate processes controlling recruitment and priming winter survival in ecological key taxa, such as diatoms, Calanus copepods, ice amphipods, and polar cod, as well as conducting population genomics and transcriptomics.
- Deploy autonomous observatories to sample physical, chemical, biogeochemical, and biological parameters in sympagic and pelagic habitats, using ocean optics, chemical sensors, and automated eDNA samplers.
- Cross-validate autonomous measurements, eDNA sequence data, and abundance data from organism samples (CTD, nets, longlines).
- Examine surface sediments for cryogenic minerals, benthic foraminifera, and DNA to compare with sea ice and pelagic observations.

Work at sea

We will take biological and biogeochemical samples from a) the water column during transit between the three focus areas and during ice stations, and b) the sea-ice habitat, including the ice-water interface (IWI) and melt ponds during ice stations. Parallel sampling of microbial communities, zooplankton, benthic foraminifera and nekton, and biogeochemical parameters will ensure a system perspective on the biodiversity and its associated biological and biogeochemical processes in the three sea-ice regimes. Sampling, experiments and measurements will be conducted according to internationally acknowledged standard operating procedures (SOP) developed during ArcWatch-1, FRAM / LTER HAUSGARTEN, and in collaboration with the Tara Polar Station.

Microbial communities, including phytoplankton and ice algae

We will sample phytoplankton, ice algae and other microbes from filtered samples from:

1. Water column: water collected between 1,000 m depth and the surface with Niskin bottles mounted to the CTD rosette, and large-volume water samples collected from multiple depths strata with *in-situ* pumps during ice stations;
1. Sea ice: water samples from the IWI, and from melt ponds will be collected with hand pumps; sea-ice samples will be collected with ice corers and melted in the ship's laboratories according to previously established protocols during ArcWatch-1.

These samples will be used to analyze the taxonomic composition (abundance and biomass), and biodiversity of microbial and metazoan communities based on eDNA sequences, microscopic analysis as well as a planktoscope with which we will analyze live samples from water column and ice onboard. Furthermore, abundance and biomass estimates based on flow cytometry (particularly smaller organisms), imaging flow cytometry, and the concentration of chlorophyll and other pigments, and trophic biomarker sampling (sterols, fatty acids, amino acids and stable isotopes) will be carried out. Additionally, we will conduct incubation experiments to estimate primary production with the 14C method, identify mixotrophy, and quantify silicification degree of diatoms through the fluorophore PDMPO. A continuous underway record of eDNA samples will be collected with the flow-through autosampler AutoFim which pumps water from the ship's keel at 11 m depth.

Zooplankton, sea-ice fauna and nekton

1. Water column: The mesozooplankton community composition and depth distribution will be sampled with a MultiNet midi (Hydrobios, Kiel Germany) equipped with five nets of 150 µm mesh size allowing the sampling up to five depths layers (2,000-1,000-500-200-50-0 m). To analyze the vertical distribution of zooplankton species in the upper 1,000 m of the water column with high spatial resolution, the *in-situ* optical system LOKI (Lightframe On-sight Key species Investigation) will be deployed at the same stations as the MultiNet. LOKI is equipped with a 150 µm plankton net and takes images of zooplankton organisms and particles at a rate of approx. 20 frames sec^{-1} while being towed vertically through the water column. Simultaneously, depth, temperature, oxygen content and fluorescence are being recorded to relate the zooplankton abundance to the environmental conditions. LOKI captures the dominating copepods, ostracods and chaetognaths very well, however, fragile zooplankton such as gelatinous plankton is often destroyed by the net. Therefore, we will mount an Underwater Vision Profiler (UVP) on the frame of the water rosette and activate it for every CTD cast. The UVP takes images directly in the water and therefore delicate organisms remain intact, however, the resolution of the images is lower than those obtained by LOKI, and do not allow to determine mesozooplankton genera. In addition, planktonic foraminifera composition and depth distribution will be sampled using a MultiNet midi equipped with five nets of 50 µm mesh size from the same five depths layers as the mesozooplankton samples. Benthic foraminifera will be sampled with a Multiple Corer (MUC). The foraminifera samples will be immediately preserved in 70% ethanol.

2. During transit between sampling stations and during long ice station, the abundance and biomass of the zooplankton and fish community will be continuously surveyed with *Polarstern's* Simrad EK80 echosounder. With its 5 frequencies (18, 38, 70, 125, 200 kHz), this device can detect organisms from the size range of mesozooplankton up to large fishes. Macrozooplankton and fish can be detected up to about 600 m depth. The data will be in parts recorded in broadband (fm) mode, allowing for more accurate biomass estimates and better taxonomic resolution compared to the past. The acoustic data will be ground-truthed with taxonomic community composition derived from eDNA sequencing, zooplankton net catches, *in-situ* optics such as LOKI and UVP,

3. Sea ice: Under-ice fauna and zooplankton living at the IWI and down to 50 m below will be sampled under the sea ice with a net mounted on the ROV of the sea-ice physics group, the ROVnet (Wollenburg et al. 2020). This net is both capable of scraping the underside of sea ice and collecting the animals falling down, and of sampling animals dwelling in the water underneath the ice. Animals living within the sea-ice matrix (sea-ice meiofauna) will be collected from sea-ice samples collected with ice corers and processed according to the MOSAiC SOP for sea-ice meiofauna. In addition, we aim to sample polar cod with traps deployed under the ice. This will improve the potential of the next generation of autonomous observatories for monitoring zooplankton and fish in the ice-covered Arctic Ocean.

Animals for experiments and biochemical analyses (e.g. trophic biomarkers) will be sampled with a bongo net and from the ROVnet and preserved frozen at -80°C. Taxonomic samples from the multinet and the ROVnet will be preserved in buffered formaldehyde-seawater solution. In the laboratories at AWI, they will be digitized with a ZooScan. The organisms on the images from ZooScan, LOKI and UVP will be determined to the lowest taxonomical level possible via the internet application EcoTaxa. After standardizing these data with the volume of water sampled by the respective devices, we will determine zooplankton species composition and abundance. EcoTaxa also automatically provides the sizes of the organisms, and they will be used to calculate biomasses according to Cornils et al. (2022). Apart from net catches, the biodiversity and taxonomic composition of zooplankton, sea-ice fauna and nekton will be determined from sequences of the eDNA samples also collected for microbe and metazoan community analysis (see above).

Cryogenic minerals

Cryogenic minerals will be collected from ice-cores, catches with a cryogenic gypsum-net mounted in the ROVnet, water collected with the niskin bottles of the CTD and algae aggregates pipetted from the sediment surface of MUC cores. The minerals, their abundance, vertical and spatial distribution will be analysed in respect to sea ice type, temperature, area and ballasting potential. Cryogenic mineral analyses from algae aggregates will provide direct information on the importance of cryogenic minerals as ballasting source.

Biogeochemical parameters

Samples for the measurement of inorganic nutrients (nitrate and nitrite, ammonium, silicic acid, phosphate), total dissolved nitrogen and total dissolved phosphorus will be collected from melted ice cores, melt ponds, meltwater layers and the surface ocean. The samples will either be analyzed directly onboard or stored frozen and analyzed in the laboratory of the AWI using an AA3 Seal Analytical segmented continuous flow auto-analyzer.

In parallel to microbial eDNA and pigment samples from the sea ice and the water column, we will collect Particulate Organic Matter (POM) samples for the determination of carbon, nitrogen and silica contents of particles and other components, as well as the isotopic composition of carbon and nitrogen.

To study particle dynamics, we will use UVP images and sediment traps. The UVP will provide imagery of particles at various depths for size composition analysis and flux estimation. Sediment traps will collect sinking particles, enabling the investigation of vertical fluxes and the role of particles in carbon and nutrient cycling. Additionally, marine snow catchers will be deployed to capture aggregates of organic material sinking from the surface. These marine snow catchers will provide insights into the transport of organic matter to the deep sea, influencing benthic ecosystems and carbon sequestration. The *in-situ* camera system ROSINA will be used to visually study particles and macrozooplankton in their natural environment. These cameras will allow for real-time observation of particle distribution, and interactions with marine organisms. Furthermore, cryogenic minerals will be sampled from the 50 micron multinet samples and from ROV nets, ice cores, and the fluffy layer of MUC core tops.

Expected results

We expect that different ice regimes will have a significant impact on plankton communities, which will directly influence the magnitude and efficiency of carbon export to the deep ocean. The release of cryominerals will likely ballast organic aggregates, facilitating their passage through salinity gradients at the base of the meltwater layer. This will lead to sporadic export events, during which a substantial fraction of organic matter, initially retained in the meltwater layer, is transferred to the deep sea and seafloor. These episodic events may serve as key drivers of the biological carbon pump in the Central Arctic Ocean.

During periods of reduced cryomineral ballasting, the meltwater layer is expected to support high biological activity, with enhanced microbial degradation and zooplankton grazing on organic aggregates. The porous nature of these aggregates may promote their retention at the salinity gradient, allowing for prolonged remineralization before any export occurs. In highly stratified regions beneath Arctic sea ice, carbon retention is expected to dominate, with limited export unless facilitated by cryomineral ballasting or the formation of compact, dense zooplankton fecal pellets.

These factors are anticipated to shape microbial communities, leading to distinct taxonomic and metabolic shifts under different ice conditions. Additionally, we expect to observe an increased potential for microbial chemotaxis and carbon cycling in transient, productive habitats such as melt ponds.

In deeper layers below 200 m, the distribution of fish and zooplankton will be driven not by local ice conditions, but by water mass distribution and prevailing currents. We expect very low abundances of fish as detected by the EK80, but occasional spatially confined aggregations.

Preliminary data sets on the diversity of phytoplankton based on planktoscope analyses of water column, melt pool and other samples will be available at the end of the cruise with data uploaded into the Ecotaxa database for taxonomic classification. We expect these data to give us a first indication of biogeographic patterns and the extent to which ice communities 'seed' water column communities. A particular focus during the cruise will be parasitic plankton and we hope to discriminate how this differs between ice and water column.

Data management

Environmental data will be archived, published and disseminated according to international standards by the World Data Center PANGAEA Data Publisher for Earth & Environmental Science (https://www.pangaea.de) within two years after the end of the expedition at the latest. By default, the CC-BY license will be applied.

Molecular data (DNA and RNA data) will be archived, published and disseminated within one of the repositories of the International Nucleotide Sequence Data Collaboration (INSDC, www.insdc.org) comprising of EMBL-EBI/ENA, GenBank and DDBJ).

All imaging data from sensors such as UVP and planktoscope will be uploaded to the ECOTAXA database.

Any other data will be submitted to an appropriate long-term archive that provides unique and stable identifiers for the datasets and allows open online access to the data.

This part of the expedition is supported by the Helmholtz Research Programme “Changing Earth – Sustaining our Future” Topic 6, Subtopics 1, 2 and 3.

In all publications based on this expedition, the **Grant No. AWI_PS149_04** or, in case of multidisciplinary work, **AWI_PS149_00** will be quoted and the following publication will be cited:

Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung (2017) Polar Research and Supply Vessel POLARSTERN Operated by the Alfred-Wegener-Institute. Journal of large-scale research facilities, 3, A119. http://dx.doi.org/10.17815/jlsrf-3-163.

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6. MEDIA

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Grant-No. AWI_PS149_00

Objectives

As a medium, virtual reality (VR) offers an immersive portrait of Arctic climate science that is experienced through place rather than explained as a process or time. The consequences of sea-ice loss stretch globally, yet, for most people, climate change is a number, diagram or chart depicting temperature, time, and extinction. It is a negative space framing, making it difficult to feel an emotional connection to something abstract. Placing audiences inside the Arctic Ocean – inside the story – collapses the space between landscape and data, event and record, elemental encounter and scientific concept; this teaches audiences how to connect perceptual observations of place to questions that lead back to the big picture of climate change.

As a distribution channel, VR reaches a sector of the public searching for cool VR experiences, including a segment of the public not actively seeking out climate science content.

A VR experience that also:

1. communicates the system-wide process changes that result from an Arctic Ocean now dominated by seasonal and younger ice covers and why the CONTRASTS programme is necessary for reducing uncertainties in climate modelling and satellite derived measurements;
2. enables middle and high school classes to learn about climate change through an educational package that will include a film and accompanying art and science curricula;
3. reaches a segment of the public not actively seeking out factual climate science content to bridge the knowledge gap between institutional education and engaging public outreach initiatives;
4. builds on a growing series of polar VR experiences – the first immersive storytelling series to focus solely on polar oceans – that researches the impact of immersive storytelling on public understanding of and engagement with climate science topics.

Beyond the VR work, a comprehensive outreach program will communicate the expedition with its objectives, realization and expected results to international audience.

Work at sea

Work at sea involves capturing 3D/360° audio-visual content for a VR experience. Structurally, the VR experience will follow the CONTRASTS cruise schedule and document both the travel and science conducted at each of the three field sites. The VR experience has three layers of story: the specific science conducted during the cruise, the expedition itself, and the bigger picture of Arctic climate science. Audiences will experience the story of the specific science conducted during the cruise on the ice during field measurements. The scientists will address the audience directly through interviews conducted at each field site. The scientists will speak directly to the camera to create a viewer experience of being part of the scientific team. Audiences will experience the big picture story of the Arctic climate system and process-wide changes while traveling from one site to the next. Narrations paired with video and time-lapses taken from the same spot at the front of the ship every day will connect the Arctic climate system with the specific scientific work conducted during the cruise. The story of the 2025 expedition itself will be experienced as B-roll, in the moments between the transects and on ice work.

We will create media content for video, photo, audio and print contributions to various types of media with a focus on online media. This will create a media pool with well documented material (incl. metadata) as a basis for our media work during the expedition. We will communicate with this material live from the expedition and beyond the return of the vessel. Broadband internet connection of *Polarstern* will be used and informations fed into web pages and media channels. In addition, we will feed the usual communication channels of the different partner institutes of the expedition.

Expected results

The current series of polar ocean VR documentaries includes two published films: “Into the Polar Night” (2020) and “The Arctic Halocline” (2023). The science lesson in “Into the Polar Night” (2020) centers on system-wide feedback loops; the lesson in “The Arctic Halocline” (2023) focuses on ocean stratification. “Arctic Melt” (2026) is designed to teach audiences about sea ice and address commonly held myths concerning ice melt and growth processes. “Arctic Melt” will approach sea ice as a complex material that grows, moves, melts, and acts differently as a seasonal ice-cover in the marginal ice zone, year-round mixture of First-Year Ice (FYI) and multi-year ice (MYI) along the transpolar drift system, and year-round MYI in the Last Ice Area north of Greenland. Through a material lens, audiences will learn about system-wide energy budgets, the concept of cycles within cycles, and the relationship between satellite and field derived measurements.

We expect to communicate science to various audiences on land through news feeds (print and online), videos of different lengths and foci, and into existing social media channels with a broad audience.

Data management

The VR film will be made publicly available to all CONTRASTS participants and affiliated institutions for education and outreach initiatives, conferences, and workshops.

In all publications based on this expedition, the **Grant No. AWI_PS149_00** will be quoted and the following publication will be cited:

Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung (2017) Polar Research and Supply Vessel POLARSTERN Operated by the Alfred-Wegener-Institute. Journal of large-scale research facilities, 3, A119. http://dx.doi.org/10.17815/jlsrf-3-163.

APPENDIX

A.1 TEILNEHMENDE INSTITUTE / PARTICIPATING INSTITUTES

A.2 FAHRTTEILNEHMER:INNEN / CRUISE PARTICIPANTS

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Walbröl	Andreas	DE.UNI-Köln	Scientist	Meteorology
Webster	Melinda	US.APL-UW	Scientist	Geophysics
Welteke	Nahid	DE.UNI-DUE	Student (Master)	Chemistry
Wenzel	Anna Julia	DE.DWD	Scientist	Meteorology
Wollenburg	Jutta	DE.AWI	Scientist	other Geo sciences
Zimmer	Florian	DE.AWI	PhD student	Geophysics

A.3 SCHIFFSBESATZUNG / SHIP‘S CREW PS149

No.	Nachname / Last name	Vorname / First name	Rank / Position
1	Kentges	Felix	Master
2	Langhinrichs	Jacob	Chief Mate
3	Janik	Michael	Chief Mate Cargo
4	Hering	Igor	2nd Mate
5	Rathke	Wulf Jannik	2nd Mate
6	Gößmann-Lange	Petra	Doctor
7	Grafe	Jens	Chief Engineer
8	Farysch	Tim	2nd Engineer
9	Brose	Thomas Christian Gerhard	2nd Engineer
10	Loske	Sven	2nd Engineer
11	Zivanov	Stefan	Ship Electrotechnical Officer Engine
12	Jäger	Vladimir	Electrotechnical Engineer Winches
13	Müller	Andreas	Electrotechnical Engineer Network/Bridge
14	Hüttebräucker	Olaf	Electrotechnical Engineer Labor
15	Pliet	Johannes	Electrotechnical Engineer System
16	Sedlak	Andreas	Bosun
17	Neisner	Winfried	Carpenter
18	Klee	Philipp	Multi Purpose Rating Deck
19	Burzan	Gerd-Ekkehard	Multi Purpose Rating Deck
20	Fischer	Sascha	Multi Purpose Rating Deck
21	Klähn	Anton	Multi Purpose Rating Deck
22	Kryszkiewicz	Maciej Waldemar	Multi Purpose Rating Deck
23	Haller	Fabian	Multi Purpose Rating Deck
24	Bäcker	Andreas	Multi Purpose Rating Deck
25	Röth	Benedikt	Multi Purpose Rating Deck
26	Ackenhausen	Hendrik	Able Seaman

No.	Nachname / Last name	Vorname / First name	Rank / Position
27	Preußner	Jörg	Storekeeper
28	Rolofs	Nils Christian Timo	Multi Purpose Rating Engine
29	Hänert	Ove	Multi Purpose Rating Engine
30	Klinger	Dana	Multi Purpose Rating Engine
31	Loew	Caspar	Multi Purpose Rating Engine
32	Münzenberger	Börge	Multi Purpose Rating Engine
33	Hofmann	Werner	1st Cook
34	Hammelmann	Louisa	2nd Cook
35	Dietrich	Emilia Felizitas Ilse Lieselotte	2nd Cook
36	Brändli	Monika	1st Stewardess
37	Naundorf	Katharina	2nd Stewardess
38	Dibenau	Torsten	2nd Steward
39	Möhle	Steffi	2nd Stewardess
40	Schwantes	Andrea	2nd Stewardess / Nurse
41	Arendt	Rene	2nd Steward / Laundry
42	Cheng	Qi	2nd Steward / Laundry
43	Chen	Dansheng	2nd Steward / Laundry