Colección **Congresos** y **Homenajes** *Serie* **Congresos**

ASOF

21st Arctic-Subarctic Ocean Fluxes Workshop

10-12 May, 2023. Gran Canaria, Spain

EBOOK

ULPGC ediciones

21st Arctic-Subarctic Ocean Fluxes Workshop

Gran Canaria, Spain
10-12 May, 2023

Coord:
María Dolores Pérez Hernández
Instituto de Oceanografía y Cambio Global (IOCAG)
UNIVERSIDAD DE LAS PALMAS DE GRAN CANARIA

ULPGC
Universidad de Las Palmas de Gran Canaria

2023

Colección **Congresos** y
Homenajes *Serie* **Congresos**

ARCTIC-SUBARCTIC OCEAN FLUXES WORKSHOP (21º. 2023. Las Palmas de Gran Canaria)
21st Arctic-Subarctic Ocean Fluxes Workshop [Recurso electrónico] : Gran Canaria, Spain, 10-12 May, 2023 / coord., María Dolores Pérez Hernández. -- Las Palmas de Gran Canaria : Universidad de Las Palmas de Gran Canaria, Servicio de Publicaciones y Difusión Científica, 2023
1 archivo PDF (79 p.). -- (Congresos y Homenajes. Serie Congresos)
ISBN 978-84-9042-515-2
1. Circulación oceánica – Océano Ártico – Congresos y conferencias 2. Circulación oceánica –Atlántico Norte – Congresos y conferencias I. Pérez Hernández, María Dolores, coord.. II. Universidad de Las Palmas de Gran Canaria, ed. III. Título IV. Serie
551.465(268)(261.1)(063)

Thema: RBKC, 1QSR, 1QMD

21st Arctic-Subarctic Ocean Fluxes Workshop

Gran Canaria, 10-12 May, 2023

© 1ª edición, 2023
Universidad de Las Palmas de Gran Canaria
Servicio de Publicaciones y Difusión Científica
serpubli@ulpgc.es
https://spdc.ulpgc.es/

Primera edición [electrónica PDF], Las Palmas de Gran Canaria, 2023

© María Dolores Pérez Hernández
(coordinadora)

© de los textos y de las imágenes: sus autores

Editorial:
Servicio de Publicaciones y Difusión Científica de la ULPGC

ISBN: 978-84-9042-515-2

https://doi.org/10.20420/1742.2023.648

Outline

Meeting Agenda

All times are given in local Canary Islands time, which is UTC+1. (O) – Online presentation

Day 0.

Ice breaker

Real Club Náutico de Gran Canaria, Salón Almirante. Come to pick up your badge and get familiar with the venue on May 9th between 18:00 and 20:00.

Real Club Náutico de Gran Canaria, Salón Dámaso.

Posters available for discussion throughout the meeting

Ian Renfrew	An evaluation of surface meteorology and fluxes over the Iceland and Greenland Seas in ERA5 reanalysis: The impact of sea ice distribution.
Svenya Chripko	Effect of Marine Cold Air Outbreaks on Water Masses and Circulation in the Nordic Seas.
Francesca Doglioni	The Greenland ice sheet–Ocean interaction (GROCE) programme: process-based understanding of the basal melt of the 79NG.
Kjetil Våge	Pathways of dense overflow water from the Greenland Sea to Denmark Strait.
Thorbjørn Østenby Moe	Idealized Modelling of the Circulation Along the Slope North of Iceland.
Nick Foukal	Lagrangian perspectives of the shelf circulation around southern Greenland.
Wilken-Jon von Appen	Atlantic Water pathways to the ice, first results from summer 2022.
Alexandra Jahn	Fundamental changes in the North Water Polynya less likely if global warming is limited to 2 degrees.
Thomas Haine	Tutorial on volume, heat, and freshwater budgets.
Marta Umbert	Arctic Freshwater content measured with SMOS and TOPAZ reanalysis
Eva De Andrés	Tracking and quantifying sea-ice meltwater from SMOS SSS in the Beaufort Gyre.
Joan Mateu Horrach Pou	Deep weakly-stratified layers in the Greenland Sea.
Ingrid Sælemyr	CO2 dynamics in the Greenland Sea as observed by Argo floats.

Photographic exhibition available throughout the meeting: *Una mirada polar*

Few geographic areas of our planet are as fascinating and, at the same time, as unknown, as the polar regions. Their great scientific interest lies in the important and decisive role they play in the dynamics and future of our planet, especially in the present context of global change, since the polar regions are the principal regulating motors of the Earth's climate. The drastic changes that are occurring in response to the global increase in temperature, caused by the increase in the emission of greenhouse gases as a consequence of human activities, are directly affecting the climatic, oceanographic, and environmental dynamics, both at the poles themselves and at subpolar latitudes. This photography exhibition seeks to show the beauty of these remote regions as well as to provide a comprehensive and multidisciplinary vision of the state of knowledge of the polar zones, highlighting the similarities and differences between the Arctic and Antarctica. In particular, it seeks to make new generations aware of the importance and vulnerability of the polar regions. In addition, it aims to highlight the need for research focused on understanding and evaluating its role in the uncertain future of our planet in a context of transformation derived from the current global change.

Day 1- Real Club Náutico de Gran Canaria, Salón Dámaso.

Welcome and house keeping

0800-0830 Lola, Tom, Michael

0830-10:30 6 talks, 20 min each

Atlantic Ocean circulation (5 talks)

Helene Asbjørnsen	Observed changes and coherence in the Gulf Stream system.
Helen Johnson	A Lagrangian view of seasonal overturning variability in the eastern North Atlantic subpolar gyre.
Johanne Skrefsrud	Structure and sensitivity of the North Atlantic circulation system.
Verónica Caínzos	Thirty years of GO-SHIP and WOCE data: Atlantic overturning of mass, heat, freshwater, and anthropogenic Carbon transport.
Hjálmar Hátún	Monitoring key branches of the Atlantic Meridional Overturning Circulation (AMOC) for more than 25 years

Atlantic Inflow regions (6 talks)

Francesco De Rovere (IASC supported ECS)	Winter Atlantic Water intrusions in Kongsfjorden: atmospheric triggering and oceanic preconditioning.

1030-1100 Coffee Break

1100-1300 6 talks, 20 min each

Zerlina Hofmann	Subduction as Observed at a Submesoscale Front in the Marginal Ice Zone in Fram Strait.
AHAMMED SHEREEF MS (O)	Shelf-fjord Exchanges in Northwest Svalbard.
M. Dolores Pérez-Hernández	Eddy flux of Atlantic Water to the Eurasian Basin North of Svalbard.
Finn Ole Heukamp	Atmospheric Blocking Disturbing the Transports through the Barents Sea Opening.
Torsten Kanzow	Structure and seasonal variability of the Arctic Boundary Current north of Severnaya Zemlya.

1300-1430 Lunch Break

Arctic Ocean (12 talks)

1430-1610 5 talks, 20 min each

Wiebke Körtke	Changes in the Atlantic Water circulation seen in CFC-12 and SF6 tracer ages in the central Arctic Ocean.
Francesca Pereira	Underwater Acoustics in a Spicy Arctic.
Thomas Spengler	Sensitivity of Atmosphere-Ocean interactions to characteristics of the sea-ice edge, lead width and orientation, and model resolution.
Hiroshi Sumata	Regime shift in Arctic Sea ice thickness distribution observed in Fram Strait.
Camille Lique (O)	Understanding the variability of the Eddy Kinetic Energy in the Arctic Ocean.

1610-1640 Coffee Break

1640-1820 5 talks, 20 min each

Ivan Kuznetsov	Upper-ocean eddy dynamics in the Central Arctic during winter: an observational model-assisted reanalysis of the MOSAiC expedition.
Hege-Beate Fredriksen	Inverse estimates of volume, heat and freshwater fluxes in the Arctic gateways.
Benjamin Rabe (O)	Upper ocean turbulence and vertical mass fluxes from in-situ observations in the central Arctic Ocean 2015.
Ruijian Gou (O)	High-resolution climate model suggests an increase in Arctic amplification and high-latitude marine extremes in the 21st century.
Clemens Spensberger(O)	Attribution of air-ice-sea interactions to cyclones, fronts, and cold-air outbreaks.

1820 **Adjourn**

Day 2 - Real Club Náutico de Gran Canaria, Salón Dámaso.

0830-10:30 6 talks, 20 min each

Francesca Doglioni	Wind forcing of cross-slope transport in the Eurasian Arctic and implications for ocean circulation.

Bering Strait, Canadian Arctic (9 talks)

Rebecca Woodgate (O)	What's new in the Bering Strait?
Nan-Hsun Chi	Saildrone observed internal wave generation in seasonal ice-free Chukchi Sea shelf.
Annabel Payne (IASC supported ECS)	Circulation timescales in the Canada Basin: Insights from transient tracers 129-iodine and 236-Uranium.
Clark Richards (O)	Two decades of ocean observations in the Canadian Arctic Archipelago

1030-1100 Coffee Break

1100-1300 6 talks, 20 min each

Jie Huang (O)	Structure and variability of the Barrow Canyon outflow from two high-resolution shipboard surveys in 2018.
Peigen Lin (O)	Formation and circulation of Newly Ventilated Winter Water in the western Beaufort Sea.
Qiang Wang (O)	On the release of freshwater from the Beaufort Gyre

Fram Strait outflows, EGC and EG shelf (4 talks)

Miriam Bennett (IASC supported ECS)	Atmospheric Forcing and Oceanic Response of the Northeast Water Polynya.
Theodoros Karpouzoglou (IASC supported ECS)	Three Forcing Mechanisms of Freshwater Transport in Fram Strait.
Rebecca McPherson	Shifts of the Recirculation Pathways in Fram Strait drive Atlantic Water Variability on Northeast Greenland shelf.

1300-1430 Lunch Break

1430-1550 4 talks, 20 min each

Claudia Wekerle (O)	High-resolution simulation of the ocean circulation beneath the 79°North Glacier in North East Greenland.

Nordic Seas and Iceland (13 talks)

Veronica Arnone	Distribution of copper-binding ligands in Fram Strait and influences from the Greenland Shelf.
Anna-Marie Strehl	A 70-year perspective on convection in the Greenland Sea.
Lucas Rodrigues de Almeida	Recent weakening of the open ocean convection in the Greenland Sea.

1550-1620 Coffee Break

1620-1800 2 a 20 plus 40 min buffer

Stefanie Semper	Dense-water formation in the northwestern Iceland Sea.
Santiago Hernández León	Enhanced zooplankton biomass in the bathypelagic zone of the Subarctic Ocean.
Caroline Gjelstrup	Insights into the fate of Arctic derived dissolved organic matter in a subarctic sea.

18:30 Bus outside.

19:00 Guided visit to the historic quarter of Vegueta.

The visit starts at the Pérez Galdós Theatre. It will last 1.30 hours and will finish an area full of restaurants.

Day 3 - Real Club Náutico de Gran Canaria, Salón Dámaso.

0830-10:30 6 talks, 20 min each

Ian Renfrew	Coupled atmosphere–ocean observations of a cold-air outbreak and its impact on the Iceland Sea.
Marius Årthun (O)	Surface-forced variability in Nordic Seas overturning circulation and overflows.
Sourav Chatterjee (O)	Impact of large-scale ocean circulations on heat content variability in the Lofoten Basin.
Ruiqi Shu (O)	Slantwise Convection in the West Greenland Current.
Steingrímur Jónsson	The role of ocean circulation and associated changes in ocean heat transport in affecting the climate in Iceland.

1030-1100 Coffee Break

1100-1300 6 talks, 20 min each

Around Greenland to Davis Strait and the Labrador Sea (4 talks)

Paul Myers	Freshwater Exchange Between the Arctic and Sub-Polar North Atlantic.
Jed Lenetsky	An updated observational record of Davis Strait ocean transports, 2004-2017.
Louis Clement	Cessation of Labrador Sea Convection by Freshening through (Sub)mesoscale Flows.

Subpolar Atlantic Arctic (7 talks)

Duncan Dale (IASC supported ECS)	The benefits of nuclear waste: Insights into Subpolar North Atlantic Ocean circulation using artificial radionuclide tracers.
Maxi Castrillejo	Marine radiocarbon changes in the North Atlantic since the 1990s
Kevin Niklas Wiegand	Assessing the variability of Irminger Water at AR7W between 1993 and 2022 using time-dependent property thresholds.

1300-1430 Lunch Break

1430-1550 4 talks, 20 min each

John N. Smith (O)	Time series measurements of transient tracers and tracer derived transport in the Deep Western Boundary Current off Bermuda.
Eleanor Frajka-Williams (O)	Relating subpolar watermass transformation to subtropical overturning.
D. Gwyn Evans	Mixing and air-sea buoyancy fluxes set the time-mean overturning circulation in the subpolar North Atlantic and Nordic Seas.
Lorenza Raimondi	A quasi-synoptic estimation of Anthropogenic Carbon Inventories in the Arctic Ocean and Subpolar North Atlantic in 2015.

1550-1620 Coffee Break

Short project talks (~10 min each)

1620-17:40 7 talks, 10 min each

Maria Teresa Bezem (O)	Synoptic Arctic Survey maps climate change in the Arctic Ocean.
Anna Nikolopoulos (O)	Developing a pan-Arctic network of Distributed Biological Observatories (DBOs).
Angel Ruiz-Angulo	Iceland Faroe GLider Ocean Observations (IFGLOO) project.
Bob Pickart	A new field program investigating dense water pathways to the Faroe Bank overflow
Kjetil Våge	A new field program investigating water mass transformation in the East Greenland Current
Anna Sanchez Vidal (O)	Investigating the far-reaching impacts of dense water overflows in the North Atlantic Ocean: the 2023 FARDWO cruise in the Denmark Strait.
Nicholas Foukal	Transport and fate of the Labrador Coastal Current: plan for 2023 fieldwork
Andreas Macrander (O)	Physical oceanography around Iceland: Present and future research of Hafrannsóknastofnun

1740-1820

Final discussion (ASOF next steps, any other issue)

1820 **Adjourn**

Posters available for discussion throughout the meeting

An evaluation of surface meteorology and fluxes over the Iceland and Greenland Seas in ERA5 reanalysis: The impact of sea ice distribution.

I. A. Renfrew[1], C. Barrell1 A. D. Elvidge[1], J. K. Brooke[2], C. Duscha[3], J. C. King[4], J. Kristiansen[5], T. Lachlan Cope[4], G. W. K. Moore[6], R. S. Pickart[7], J. Reuder[3], I. Sandu[8], D. Sergeev[9], A. Terpstra[1,3], K. Våge[3] and A.Weiss[4]

[1] School of Environmental Sciences, University of East Anglia, Norwich, UK
[2] Met Office, Exeter, UK
[3] Geophysical Institute, University of Bergen and Bjerknes Centre for Climate Research, Bergen, Norway
[4] British Antarctic Survey, Cambridge, UK
[5] Norwegian Meteorological Institute, Oslo, Norway
[6] Department of Physics, University of Toronto, Toronto, Canada
[7] Woods Hole Oceanographic Institution, Woods Hole, Massachusetts
[8] European Centre for Medium-range Weather Forecasts, Reading, UK
[9] College of Engineering, Mathematics and Physical Science, University of Exeter, Exeter, UK

ABSTRACT

The Iceland and Greenland Seas are a crucial region for the climate system, being the headwaters of the lower limb of the Atlantic Meridional Overturning Circulation. Investigating the atmosphere–ocean–ice processes in this region often necessitates the use of meteorological reanalyses—a representation of the atmospheric state based on the assimilation of observations into a numerical weather prediction system. Knowing the quality of reanalysis products is vital for their proper use. Here we evaluate the surface-layer meteorology and surface turbulent fluxes in winter and spring for the latest reanalysis from the European Centre for Medium-Range Weather Forecasts, i.e., ERA5. In situ observations from a meteorological buoy, a research vessel, and a research aircraft during the Iceland–Greenland Seas Project provide unparalleled coverage of this climatically important region. The observations are independent of ERA5. They allow a comprehensive evaluation of the surface meteorology and fluxes of these subpolar seas and, for the first time, a specific focus on the marginal ice zone. Over the ice-free ocean, ERA5 generally compares well to the observations of surface-layer meteorology and turbulent fluxes. However, over the marginal ice zone, the correspondence is noticeably less accurate: for example, the root-mean-square errors are significantly higher for surface temperature, wind speed, and surface sensible heat flux. The primary reason for the difference in reanalysis quality is an overly smooth sea-ice distribution in the surface boundary conditions used in ERA5. Particularly over the marginal ice zone, unrepresented variability and uncertainties in how to parameterize surface exchange compromise the quality of the reanalyses. A parallel evaluation of higher-resolution forecast fields from the Met Office's Unified Model corroborates these findings.

Effect of Marine Cold Air Outbreaks on Water Masses and Circulation in the Nordic Seas.

Chripko, S.[1,*] and Spengler, T.[1]

[1] Geophysical Institute, University of Bergen, and Bjerknes Center for Climate Research, Bergen, Norway

[*]Fundación DISA supported Early Career Scientist

ABSTRACT

Mesoscale atmosphere-ocean interaction processes in the Arctic, such as marine cold air outbreaks (MCAOs), are often poorly represented in weather and climate prediction models. Yet, the energy exchange associated with these events can have a significant impact on the atmospheric heat and water content, as well as the ocean mixed layer. In the Nordic Seas, where crucial warm-to-cold water mass transformation occurs, MCAOs have a significant effect on the Atlantic Meridional Overturning Circulation. However, the processes through which MCAOs affect this water mass transformation and the ocean circulation remain unclear, with possible competing effects occurring in the boundary currents and in the interior of the Nordic Seas. We investigate the impact of air-sea heat exchange during MCAOs events in the Nordic Seas, shedding light on the role of MCAOs on water mass properties and dynamics. We use a combination of atmospheric (ERA5) and ocean (TOPAZ4, GLORYS12) reanalyses data to characterize the spatial dependence of the ocean response to MCAOs. By classifying the events according to their location, intensity, and duration, we focus on the ocean response in terms of heat and salt content, stratification, as well as dynamics. We propose mechanisms linking the atmosphere-ocean energy exchanges during MCAOs to the concomitant changes in the boundary current regions and the interior region of the Nordic Seas.

The Greenland ice sheet–Ocean interaction (GROCE) programme: process-based understanding of the basal melt of the 79N.

Thomas Mölg[2], Torsten Kanzow[1], Mirko Scheinert[3] and Angelika Humbert[1]

[1] Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung, Bremerhaven, Germany
[2] Institute of Geography, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Erlangen, Germany
[3] Institut fur Planetare Geodäsie, Technische Universität Dresden, Dresden, Germany

ABSTRACT

About 25% of the current global mean sea level rise is caused by the mass loss of the Greenland Ice Sheet, with a substantial increase of the mass loss rate in recent decades. The resulting rising Greenland freshwater input to the ocean has significant implications for the North Atlantic thermohaline circulation.

Observations of individual marine terminating glaciers show that their acceleration and thinning during the recent past is related to warmer water at the grounding line and calving front, leading to an increased basal and frontal melting. The latter may cause the glacier to thin and retreat, resulting in an acceleration of the ice flow upstream. The largest remaining floating ice tongue in Greenland is the 80 km-long one of the 79 North Glacier (79NG).

Here we present result from the GROCE (Greenland Ice Sheet-Ocean Interaction) consortium. The overall aim of GROCE is to understand critical processes and their interactions in controlling the ocean–glacier interaction with a focus on the 79NG. One important goal of the project is to provide a detailed, process-based understanding of the basal melt of the 79NG, based on in situ observations, remote sensing and numerical simulations. We cover atmospheric processes affecting the surface melt and the drainage of meltwater from supraglacial lakes to the glacier base. We study the drivers of the meltwater plume dynamics and basal melt in the cavity. For this, the effect of the drained surface meltwater entering the cavity across the grounding line as subglacial discharge is taken into account. At the same time, we quantify impacts of warm Atlantic Water entering the cavity from the Northeast Greenland continental shelf. We further display the distribution of meltwater outflow and its influence on the ocean circulation on a regional scale.

Pathways of dense overflow water from the Greenland Sea to Denmark Strait.

Kjetil Våge[1], Stefanie Semper[1], Ailin Brakstad[1], Bob Pickart[2], Jie Huang[2] and Peigen Lin [3]

[1] Geophysical Institute, University of Bergen and Bjerknes Centre for Climate Research
[2] Woods Hole Oceanographic Institution
[3] Shanghai Jiao Tong University

ABSTRACT

The densest component of the Denmark Strait Overflow Water (28.04 ≤ σθ ≤ 28.06 kg/m3) is mainly formed in the Greenland Sea and supplied to the strait by the North Icelandic Jet (NIJ) and the East Greenland Current (EGC). However, the exchange of this dense overflow water between the Greenland and Iceland Seas and its partitioning between the NIJ and EGC are unknown. Using high-resolution hydrographic/velocity transects from ships, gliders, and moorings, we determine the dense-water pathways from the Greenland Sea to Denmark Strait. While there is limited direct transport from the Greenland Sea to the central Iceland Sea, some dense water flows through gaps in the submarine ridges that separate the Greenland and Iceland Seas and permeates the Iceland Sea gyre, which appears to be the main source of the NIJ. The dense water in the NIJ and in the separated branch of the EGC, banked up along the Iceland slope, is the main supply to Denmark Strait. The dense water in the shelfbreak branch of the EGC is located too far beneath sill depth to contribute to the overflow. Our analysis suggests that the 0.5 Sv of dense Denmark Strait Overflow Water are composed of 60% dense water from the NIJ and 40% dense water from the separated EGC. To balance the mass budget, we hypothesize the existence of a recirculation of dense water from the western Iceland Sea across Kolbeinsey Ridge and/or through Spar Fracture Zone of O(0.2-0.3 Sv) into the central Iceland Sea.

Idealized Modelling of the Circulation Along the Slope North of Iceland.

Thorbjørn Østenby Moe[1]

[1]University of Bergen (UiB)

ABSTRACT

The North Icelandic Jet (NIJ) is a significant component of the lower limb of the Atlantic Meridional Overturning Circulation, supplying one third to one half of the overflow water transport through Denmark Strait, including the densest portion. Dense water masses produced within the Nordic Seas are banked up along the slope north of Iceland and can flow relatively unimpeded across the Denmark Strait sill as part of the NIJ. Using an idealized model of the north Icelandic slope, I study the fundamental dynamics of the NIJ, including the mechanisms governing its formation. I designed the model as a channel along the slope north of Iceland, initially with no external forcing. Several specific boundary conditions were then iteratively applied to the western boundary, intended to simulate combinations of Atlantic inflow and dense outflow through Denmark Strait. Additionally, configurations with differing levels of increased realism regarding both hydrography and changes in slope steepnes in the along-channel direction were simulated. I have found that the existence and structure of the NIJ are sensitive to the boundary conditions representing transport of dense water through Denmark Strait and the steepness of the slope north of Iceland. Additionally, the upstream structure and extent of the NIJ is sensitive to changes in slope steepness along the channel.

Lagrangian perspectives of the shelf circulation around southern Greenland.

Nicholas P. Foukal [1], Renske Gelderloos[2] and Robert S. Pickart[1]

[1] Woods Hole Oceanographic Institution, Woods Hole, MA, USA
[2] Johns Hopkins University, Baltimore, MD, USA

ABSTRACT

The North Icelandic Jet (NIJ) is a significant component of the lower limb of the Atlantic Meridional Overturning Circulation, supplying one third to one half of the overflow water transport through Denmark Strait, including the densest portion. Dense water masses produced within the Nordic Seas are banked up along the slope north of Iceland and can flow relatively unimpeded across the Denmark Strait sill as part of the NIJ. Using an idealized model of the north Icelandic slope, I study the fundamental dynamics of the NIJ, including the mechanisms governing its formation. I designed the model as a channel along the slope north of Iceland, initially with no external forcing. Several specific boundary conditions were then iteratively applied to the western boundary, intended to simulate combinations of Atlantic inflow and dense outflow through Denmark Strait. Additionally, configurations with differing levels of increased realism regarding both hydrography and changes in slope steepnes in the along-channel direction were simulated. I have found that the existence and structure of the NIJ are sensitive to the boundary conditions representing transport of dense water through Denmark Strait and the steepness of the slope north of Iceland. Additionally, the upstream structure and extent of the NIJ is sensitive to changes in slope steepness along the channel.

Atlantic Water pathways to the ice, first results from summer 2022.

Wilken-Jon von Appen[1] and Torsten Kanzow[1]

[1] Alfred Wegener Institute, Germany

ABSTRACT

In July/August 2022 RV Polarstern conducted a cruise ("Atlantic Water pathways to the ice": ATWAICE) in Fram Strait and in the marginal ice zone (MIZ) north of Svalbard. Here we give an overview of the current status of the long term observations by AWI in Fram Strait that were serviced on this cruise. For example, these show how the temperature in the West Spitsbergen Current in the 2020s compares to the variability observed in the 2010s. We also outline the activities that we performed in 2022 in the MIZ in order to get a better understanding of the Atlantic Water's role in melting ice in the MIZ. In particular, we present the first results from a 150km long towed transect from the open water across the MIZ into the pack ice (100% ice concentration, 1-1.5m ice thickness including small ridges). It was collected over two 8h and 6h long stretches (separated by 2.5 days of other activities for logistical reasons) by the Triaxus towed undulating vehicle. The horizontal resolution was 800m; at a maximum depth of 150m, profiling was achieved to 10m below the surface in the outer MIZ and 15-20m below the surface in consolidated ice. This was also the first deployment of such a platform under sea ice; we briefly discuss the technical aspects. The section revealed 5 distinct regimes of stratification in the top 20m that affect the ice differently and that have direct biogeochemical and biological ramifications, which we also discuss. Warm Atlantic Water near the surface in the open water part starts the transect. North of it is the actively melting MIZ with a very localized deep chlorophyll maximum of ~35m depth. North of that the largest stratification is reached with a deep chlorophyll maximum at ~20m and a depleted stratified water column above. Further north, in the beginning of the pack ice, the productive layer is very thin and at the surface while towards the northern end of the section stratification is much weaker suggesting the absence of active meltwater input, but at the same time an easier access of the Atlantic Water to the ice as it does not need to overcome as strong a stratification.

Fundamental changes in the North Water Polynya less likely if global warming is limited to 2 degrees.

J. E. Lenetsky [1], A. Jahn[1], P. Ugrinow[1], C. R. Wyburn-Powell[1], R. Patel[1] and H. Zanowski [1,2]

[1] ATOC and INSTAAR, Univ. of Colorado Boulder, CO, USA
[2] ATOC, Univ. of Wisconsin-Madosin, WI, USA

ABSTRACT

The North Water Polynya (NOW) is one of the most productive biological regions in the Arctic with high importance to Inuit and Greenlandic peoples of Northern Baffin Bay. To provide insights into the potential changes of this region as global temperatures rise, we investigated the physical and biological oceanic responses of the NOW to 1.5, 2, and 3.5 degrees C of warming using the CESM1-LE climate model. We find different regimes of biological productivity for different warming levels. Under 1.5 and 2 degrees C of warming, increased polynya areas and sea ice melt occur alongside increased stratification, isolating surface waters from those at depth, leading to increased concentrations of nutrient-rich West Greenland Irminger Waters (WGIW) throughout the NOW region. These waters can replenish the surface with nutrients, leading to an increase in productivity relative to the historical simulation along the Greenlandic coastline. Under 3.5 degrees C of warming, we see a similar but stronger increases in stratification and WGIW as lower warming scenarios, leading to a decrease in biological productivity during all months of the growing season. This is because despite increased nutrient availability at depth, coastal convection is unable to counter the increased stratification and bring those nutrients to the surface. These results point to the importance of limiting global temperature increases to 2 degrees C or less in order to avoid fundamental changes of the NOW ecosystem.

Tutorial on volume, heat, and freshwater budgets.

Thomas Haine[1]

[1]Johns Hopkins University

ABSTRACT

An essential task in physical oceanography is to construct budgets of conserved quantities, like heat, salt and seawater mass, and the masses of trace chemicals. In the Arctic and subArctic oceans, for example, such budgets are routinely used to diagnose and understand the effects of natural variations and anthropogenic climate change on temperature and salinity. Traditionally, temperature variability is analyzed using a budget of heat fluxes relative to a reference temperature. Similarly, salinity variability is analyzed using so-called freshwater fluxes relative to a reference salinity. Well-documented pitfalls exist in the interpretation of these heat and freshwater fluxes, however. Yet, despite being well-documented, these pitfalls are not universally understood or accepted.

This contribution aims to improve understanding of, and to promote best-practices in, the interpretation of heat and freshwater fluxes, and the construction of their budgets.
The contribution consists of:

(i) A free, open-source, interactive, pedagogical software application called the Ocean-Flux-Budget tool.

(ii) A tutorial YouTube video demonstrating the Ocean-Flux-Budget tool, the pitfalls mentioned above, and suggested workarounds.

(iii) A document explaining the issues, with references to the original literature, and proposed best practices.

To access these resources visit https://github.com/ThomasHaine/Ocean-Flux-Budget.
At this website you can also seek advice, ask questions, and help refine understanding of ocean fluxes and budgets.

21st Arctic-Subarctic Ocean Fluxes Workshop
10-12 May, 2023. Gran Canaria, Spain

Arctic Freshwater Content measured with SMOS and TOPAZ reanalysis.

M. Umbert[1], E. De Andrés[1], M. Sánchez-Urrea[1] and C. Gabarró[1]

[1] Institut de Ciènces del Mar, Consejo Superior de Investigaciones Científicas, Barcelona, Spain.

ABSTRACT

According to several studies, the liquid freshwater content (FWC) in the Beaufort Gyre has considerably increased over the last two decades. Variations in freshwater fluxes within the Arctic likely affect the global thermohaline circulation and have an impact on the global climate. However, the exact effect of the Arctic freshwater increase remains unclear due to the scarcity of measurements in the region. Traditionally, the Arctic Ocean's FWC has been estimated using in situ measurements, as well as with the combination of Gravity Recovery and Climate Experiment (GRACE) and altimetry satellite data.

In this work, we have computed the FWC combining sea surface salinity from the Soil Moisture and Ocean Salinity (SMOS satellite mission) and in-depth ocean salinity from TOPAZ4b reanalysis. The SMOS SSS v3.1 product is available from 2012 to 2019, therefore we have computed the FWC during that period setting Sref = 34.8 psu as the salinity reference value. Furthermore, we aimed to determine whether sea surface salinity (SSS) variations could serve as a proxy for FWC variability in certain regions of the Arctic Ocean.

We found that the FWC computed using salinity from SMOS and TOPAZ together can be very similar to that previously reported from in situ observations, depending on the surface layer thickness where we impose SMOS SSS. Therefore, we attempted to determine the optimal surface layer thickness, examining its impacts at 5, 10, 15, and 20 m depth. We observed that the SMOS surface layer is fresher than TOPAZ 4b, and that the variation of the first salinity layer depth has a non-negligible impact on the computed FWC. According with previous studies, we would like to study if SMOS SSS could be a proxy of FWC in some Arctic regions.

This research is being conducted within the framework of European Space Agency ESA ARCTIC+SSS project and the Spanish-funded ARCTIC-MON project.

Tracking and quantifying sea-ice meltwater from SMOS SSS in the Beaufort Gyre.

E. De Andrés[1], M. Umbert[1], M. Sánchez-Urrea[1]and C. Gabarró[1]

[1] Institut de Ciències del Mar, Consejo Superior de Investigaciones Científicas, Barcelona, Spain.

ABSTRACT

Along with the Arctic water cycle intensification, the sea ice cover is getting younger, thinner, and more mobile. The observed sea ice loss has a direct impact on the Arctic Ocean freshening. In the Beaufort Gyre (BG) the liquid freshwater content within the water column has increased by 40% in the last two decades. The main factors contributing to this freshening are the melting of the Greenland Ice Sheet and glaciers, enhanced sea-ice melt, an increase of river discharge, increase in liquid precipitation and an increase of Pacific Ocean water influx through the Bering Strait. However, although big efforts have been done, in situ observations are sparse in time and the net contribution of each component remains poorly constrained.

In this study we use satellite observations of sea surface salinity (SMOS SSS), sea ice concentration (OSISAF SIC) and model-based sea ice thickness (ORAS5 SIT) from 2012 to 2019 to detect meltwater lenses (MWL) from sea ice melting in the Beaufort Gyre. We first compare the temporal evolution of SSS and sea ice concentration in the whole Arctic and in the Beaufort Gyre. Then, we analyze the residence time at the surface of these MWL, their potential convergent/divergent dynamics and routes. Our ultimate goal will be to quantify their freshwater contribution to the Beaufort Gyre.

Our results show a positive correlation between sea ice extension and SMOS SSS in the Arctic Ocean. However, the BG region is largely covered by sea ice from mid October to the end of June, having September the largest ice-free surface month. We found that SMOS SSS is able to retrieve information of fresher water lenses from sea ice melting in September. The MWL's salinity ranges from 19 psu at the beginning of the sea ice retreat to 25 psu before total dilution or sea ice formation. Some of these MWL are trapped in wind-driven anticyclonic eddies, remaining at the sea surface up to 12 days. Preliminary results show that the freshwater released within these MWL could explain a big part of the dissimilarities found between observational and modeled freshwater content in the Beaufort Gyre.

This research is partially funded by the EU Next-Generation program and conducted within the framework of the ESA ARCTIC+SSS and the Spanish ARCTIC- MON projects.

Deep weakly-stratified layers in the Greenland Sea.

Joan Mateu Horrach Pou[1], Kjetil Våge[2] and Ailin Brakstad[2]

[1]Norwegian Meteorological Institute, University of Bergen, Norway.
[2]Geophysical Institute, University of Bergen and Bjerkness Centre for Climate Research, Norway

ABSTRACT

Deep weakly-stratified layers in the Greenland Sea constitute a mode of convection poorly understood. The Greenland Sea is where the densest portion of the overflow waters on either side of Iceland are formed through wintertime convection. Deep interior weakly-stratified layers are isolated from the surface in summer, so traditional routines used to determine the mixed-layer depth are not able to detect them. Hence, open questions remain regarding the location, timing and relevance of interior weakly-stratified layers in dense water formation. We developed a novel routine to identify weakly-stratified layers and applied it to a historical hydrographic data set to identify weakly-stratified layers present in the Greenland Sea. Our findings suggest that deep layers form in years of strong atmospheric forcing in winter and positive surface salinity anomalies in autumn. Moreover, by using hydrographic surveys and Argo float data we constructed a case study of a specific type of structure containing deep weakly-stratified layers named sub-mesoscale coherent vortices (SCVs). We suggest that SCVs can live in the Greenland Sea for up to one year, although further investigation is needed to determine their typical endurance and formation. Moreover, we know that collapsing SCVs can release their core water to the ambient and, even though this water is dense enough to contribute to the overflow waters on both sides of Iceland, their relevance may be neglectable. This could indicate that the role of these structures is preconditioning the convective region and transporting weakly-stratified water along the rim current in the Greenland Sea.

CO2 dynamics in the Greenland Sea as observed by Argo floats.

Ingrid Sælemyr[1]

[1]University of Bergen, Norway

ABSTRACT

The Greenland Sea is an important region for sequestration of anthropogenic carbon, so understanding carbon fluxes in this region is necessary to improve our understanding of the biogeochemical dynamics, and in turn the response to climate change. Here, a profiling Argo float equipped with hydrographic and biogeochemical sensors was deployed in June 2019 and remained in the region for a full year. In the here presented work I combine this data with a one-dimensional mixed layer model to determine different carbon fluxes. The original model is specifically tuned for the Greenland Sea and in this work modified to include air-sea gas exchange of CO2 and O2, and biogeochemical tracers. The model output enables us to quantify the respective contributions of different fluxes to the total carbon balance: air-sea gas exchange, different vertical carbon fluxes, as well as biological uptake and release of carbon. I quantify how much of the CO2 absorbed from the atmosphere is mixed into deep layers, how deep these layers are, how much dissolved inorganic carbon (DIC) is mixed back to the surface layer in winter, and how these processes affect gas exchange at the surface throughout the annual cycle. Finally, I compare net community production (NCP) values calculated from DIC to those from O2 and nitrate.

May 10th, First day of talks.

ATLANTIC OCEAN CIRCULATION

Observed changes and coherence in the Gulf Stream system.

Helene Asbjørnsen[1], Tor Eldevik[1], Helen L. Johnson[2], Johanne Skrefsrud[1], Alejandra Sanchez-Franks[3]

[1] Geophysical Institute, University of Bergen, and the Bjerknes Centre for Climate Research
[2] Department of Earth Sciences, University of Oxford
[3] National Oceanography Centre, Southampton

ABSTRACT

The Gulf Stream system carries warm water poleward and thus maintains a mild, maritime climate in northwestern Europe while also facilitating for dense water formation feeding the deep ocean. The sensitivity of North Atlantic circulation to future greenhouse gas emissions seen in climate models has prompted an increasing effort to monitor the various circulation components in recent decades. Here, we synthesise available ocean transport measurements from the Florida Straits in the south to the Barents Sea Opening in the north and an ocean state estimate (ECCOv4-r4) for an enhanced understanding of the Gulf Stream and its poleward extensions as an interconnected circulation system. We see a limited coherence between the records on interannual time scales, highlighting the branched nature of the Gulf Stream system and the role of local responses to wind forcing. On longer time scales, we see signs of decadal trends with a weakening circulation south of the Greenland-Scotland Ridge between the mid-2000s and mid-2010s. The inflow to, and circulation in, the Nordic Seas has remained stable over the same period, indicating that changes in the North Atlantic circulation strength cannot necessarily be extrapolated to the Nordic Seas.

A Lagrangian view of seasonal overturning variability in the eastern North Atlantic subpolar gyre.

Oliver J. Tooth[1], Helen L. Johnson[1], Chris Wilson[2], and Dafydd G. Evans[3]

[1] Department of Earth Sciences, University of Oxford, UK
[2] National Oceanography Centre, Liverpool, UK
[3] National Oceanography Centre, Southampton, UK

ABSTRACT

The Atlantic Meridional Overturning Circulation (AMOC) plays a critical role in the global climate system through the uptake and redistribution of heat, freshwater and carbon. At subpolar latitudes, recent observations show that the strength of the AMOC is dominated by water mass transformation in the eastern North Atlantic Subpolar Gyre (SPG). Both observations and ocean reanalyses show a pronounced seasonality of the AMOC within this region. However, the distribution of the strength and seasonality of overturning across the individual circulation pathways of the eastern SPG remains poorly understood. To investigate the nature of this seasonal overturning variability, we use Lagrangian water parcel trajectories evaluated within an eddy-permitting ocean sea-ice hindcast simulation.

By introducing a novel Lagrangian measure of the density-space overturning, we show that water mass transformation along the circulation pathways of the eastern SPG accounts for 8.9 ± 2.2 Sv (55%) of the mean strength of AMOC in the eastern subpolar North Atlantic. Our analysis highlights the crucial role of water parcel recirculation times in determining the seasonality of overturning. We find that upper limb water parcels flowing northwards into the eastern SPG participate in a recirculation race against time to avoid wintertime diapycnal transformation into the lower limb of the AMOC. Upper limb water parcels sourced from the central and southern branches of the North Atlantic Current typically recirculate on interannual timescales (1-5 years) and thus determine the mean strength of overturning within this region. The seasonality of Lagrangian overturning is explained by a small collection of water parcels, recirculating rapidly (≤ 8.5 months) in the upper Central Iceland and Irminger Basins, whose along-stream transformation is dependent on their month of arrival into the eastern SPG.

Structure and sensitivity of the North Atlantic circulation system.

Johanne Skrefsrud[1,2], Helene Asbjørnsen[1,2], Tor Eldevik[1,2] and Marius Årthun[1,2]

[1] Geophysical Institute, University of Bergen, Bergen, Norway
[2] Bjerknes Centre for Climate Research, Bergen, Norway

ABSTRACT

In the North Atlantic, the large-scale ocean circulation transports heat poleward and freshwater equatorward, making it an integral part of the climate system. Here, the structure and sensitivity of the North Atlantic circulation system is investigated with a focus on the comparative role of the horizontal and vertical components of the circulation. We use the ECCOv4-r4 ocean state estimate to evaluate the gyre and overturning contribution in terms of climatological northward volume transport, poleward heat transport, and equatorward freshwater transport. Further, we use EOF-analysis to identify the dominant spatial patterns of temporal change in AMOC- and gyre related ocean circulation during 1992-2017. Both the gyre and overturning components are important for heat- and freshwater transport at subtropical latitudes, though the components are notably not independent of each other. From about 50oN, the gyre component is found to be the dominant contributor to the overall heat- and freshwater transport. The most dominant mode of interannual AMOC variability is a subtropical-subpolar dipole separated at about 40oN, indicating strengthened subtropical, while weakened subpolar, overturning. This pattern is highly correlated with the second EOF-mode of the gyre structure, showing a pattern of strong subtropical gyre whilst weak subpolar gyre. Both patterns are highly correlated with the NAO-index, linking the dominant AMOC pattern and parts of the gyre pattern to large-scale atmospheric variability.

Thirty years of GO-SHIP and WOCE data: Atlantic overturning of mass, heat, freshwater, and anthropogenic Carbon transport.

Verónica Caínzos[1], Alonso Hernández-Guerra[1], Antón Velo[2], Fiz F. Pérez[2], Gerard D. McCarthy[3], Elaine L. McDonagh[4,5]

[1] Unidad Océano y Clima, Instituto de Oceanografía y Cambio Global, IOCAG, Universidad de Las Palmas de Gran Canaria, ULPGC, Unidad Asociada ULPGC-CSIC, Canary Islands, Spain.
[2] Instituto de Investigaciones Marinas, CSIC, Eduardo Cabello 6, 36208 Vigo, Spain
[3] ICARUS, Department of Geography, Maynooth University, Maynooth, Ireland
[4] NORCE Norwegian Research Centre, Bjerknes Centre for Climate Research, Bergen, Norway
[5] National Oceanography Centre (NOC), Southampton SO14 3ZH, UK

ABSTRACT

The Atlantic Meridional Overturning Circulation (AMOC) plays a vital role in global climate, redistributing heat, freshwater and anthropogenic CO2 (Canth) meridionally and in depth. Accurately monitoring AMOC strength with observations has inspired a number of dedicated observing systems in the Atlantic since the 2000s. However, no consensus has been reached on whether the slowdown of the AMOC and its associated heat, freshwater and Canth transports is occurring. Hydrographic data and biogeochemical measurements from zonal sections across the Atlantic for 30 years that predate and overlap the era of AMOC observations were employed to build three inverse models, one for each of the last decades. This sections include the northern boundary of the subpolar North Atlantic at 58°N. The results show no changes in the AMOC for all sections analyzed over the whole Atlantic for the last 30 years. The change in time in the net transports of Canth appears to be mainly due to modifications in the transport of upper layers. The lower layer of the AMOC maintain more consistent transports in time. Vertical advection plays an important role in the North Atlantic, exporting Canth from upper to deep layers. The strong gradient in Canth concentration at the interphase of upper and deep layers results in a strong vertical diffusion.

Monitoring key branches of the Atlantic Meridional Overturning Circulation (AMOC) for more than 25 years.

Hjálmar Hátún[1], Karin Margretha Húsgarð Larsen[1] and Bogi Hansen[1]

[1]Faroe Marine Research Institute

ABSTRACT

The Faroe Marine Research Institute (FAMRI) has now, together with institutes from neighboring countries, monitored the Atlantic inflows and overflows across the Iceland-Scotland ridge (ISR) for more than 25 years. This successful mooring work is here reviewed, and the present status and planned activity is presented. In addition to the updated records of volume and heat transports, we present – for the first time – results from the biogeochemical sampling activity, which was added to the ISR monitoring array in 2013. Finally, we discuss major shifts in hydrographic properties at the ISR (e.g. the mid-1990s warming and salinification and the post-2015 salinity decline) in a larger biogeographical context.

ATLANTIC INFLOW REGIONS

Winter Atlantic Water intrusions in Kongsfjorden: atmospheric triggering and oceanic preconditioning.

Francesco De Rovere [1,2] *, Jacopo Chiggiato [3], Leonardo Langone [2], Angelo Rubino [1], Paolo Ruggieri [4], Francesco Caligiuri [4], Angelo Lupi [2] and Davide Zanchettin[1]

[1] Department of Environmental Sciences, Informatics and Statistics, Ca' Foscari University of Venice, Venezia, Italy
[2] CNR - National Research Council, ISP - Institute of Polar Sciences, Bologna, Italy
[3] CNR - National Research Council, ISMAR - Institute of Marine Sciences, Venezia, Italy
[4] Department of Physics and Astronomy, University of Bologna, Bologna, Italy

* IASC supported early career scientist

ABSTRACT

Kongsfjorden is an Arctic fjord in Svalbard facing the West Spitsbergen Current (WSC) transporting warm and salty Atlantic Water (AW) through the Fram Strait to the Arctic. Winter AW intrusions in Kongsfjorden occurring in the 2010-2020 decade are assessed by means of oceanographic and atmospheric observations, provided by in-situ instrumentations and reanalysis products. Winter AW intrusions are relatively common events, bringing heat and salt from the open ocean to the fjord interior; they are characterized by water temperatures rising by 1-2 °C in just a few days. Several mechanisms have been proposed to explain winter AW intrusions in West Spitsbergen fjords, tracing back to the occurrence of energetic wind events along the shelf slope. Here we demonstrate that the ocean plays a fundamental role as well in regulating the inflow of AW toward Kongsfjorden in winter.

Winter AW intrusions in 2011, 2012, 2016, 2018 and 2020 occurred by means of upwelling from the WSC, triggered by large southerly winds blowing on the West Spitsbergen Shelf (WSS) followed by a circulation reversal with northerly winds. Southerly winds are generated by the setup of a high pressure anomaly over the Barents Sea. In these winters, fjord waters are fresher and less dense than the AW current, resulting in the breakdown of the geostrophic control mechanism at the fjord mouth, allowing AW to enter Kongsfjorden. The low salinity signal is found also on the WSS and hence is related to the particular properties of the Spitsbergen Polar Current (SPC). The freshwater signal is hypothesized to be linked to the sea-ice production and melting in the Storfjorden and Barents Sea regions, as well as the accumulation of glaciers' runoff. The freshwater transport toward West Spitsbergen is thus the key preconditioning factor allowing winter AW intrusions in Kongsfjorden by upwelling, whilst energetic atmospheric phenomena trigger the intrusions.

Winter 2014 AW intrusion shows a different dynamic, i.e., an extensive downwelling of warm waters in the fjord lasting several weeks. Here, long-lasting southerly winds stack surface waters toward the coast. The fjord density is larger than the WSC density, forcing the AW intrusion to occur near the surface, then spreading vertically over the water column due to heat loss to the atmosphere.

Subduction as Observed at a Submesoscale Front in the Marginal Ice Zone in Fram Strait.

Zerlina Hofmann[1], Wilken-Jon von Appen[1] and Torsten Kanzow[1]

[1] Physical Oceanography of the Polar Seas, Alfred-Wegener-Institut, Helmholtz-Zentrum für Polar- und Meeresforschung, Bremerhaven, Germany

ABSTRACT

The marginal ice zone in Fram Strait is a highly variable environment, in which dense Atlantic Water and lighter Polar Water meet and create numerous mesoscale and submesoscale fronts. This makes it a model region for researching ocean frontal dynamics in the Arctic, as the interaction between Atlantic Water and the marginal ice zone is becoming increasingly important in an "atlantifying" Arctic Ocean. Here we present results of a front study conducted near the ice edge in central Fram Strait, where Atlantic Water subducted below Polar Water. We posit that the frontal dynamics associated with the sea ice edge also apply beyond, both to the open and the ice-covered ocean in the vicinity. They, in turn, can affect the structure of the marginal ice zone. The study comprises a total of 45 high resolution transects, most of which were oriented across the front. They were taken over the course of a week during July 2020 and include either temperature and salinity measurements from an underway CTD, or temperature and salinity measurements and various biogeochemical properties from a TRIAXUS towed vehicle. Additionally, 22 CTD stations were conducted, and 31 surface drifters were deployed. This wealth of measurements gives us the opportunity to follow the temporal and spatial development of the density fronts present at the time. Here, we discuss the distribution of water mass and biogeochemical properties of a single, representative transect of the highest available resolution. We are able to put this single transect in the horizontal and temporal context of other measurements, thus demonstrating the highly variable horizontal and temporal development of water mass distribution along the marginal ice zone in Fram Strait. We further discuss how this impacts the process of vertical subduction of biological material along these frontal zones.

Shelf-fjord Exchanges in Northwest Svalbard.

Ahammed Shereef MS[1, *]

[1]The National Centre for Polar and Ocean Research, formerly known as the National Centre for Antarctic and Ocean Research is an Indian research and development institution, situated in Vasco da Gama, Goa. INDIA

[*]Online Speaker

ABSTRACT

Climate change is likely to have a significant impact on our planet (IPCC, 2021). The warming of the Arctic region has a substantial influence on global warming and climate change. Arctic sea ice is melting rapidly (Comiso & Hall, 2014). By the 2030s, the Arctic Ocean is predicted to be seasonally ice-free (Wang & Overland, 2012). Ice melting sea and sea level rising are both interconnected so they can act like a double-sided sword in the changing global climate system.

Among others, increased temperature and inflow of the Atlantic water (AW) arriving through the Farm Strait is attributed as one of the primary reasons for the sea ice decline in the Arctic. West Spitsbergen Current (WSC), is the main driver of AW to the Arctic. The Fram Strait is the main pathway of AW exchange through which AW flows northward through the subsurface and cold Arctic water flows southward through the surface(Rudels et al., 2015). Fjords are considered a link between the ocean and the land in the polar region.

The interaction between fjord waters and AW in the Arctic fjords by shelf-fjord exchange plays an important role in glacier melting. Researchers are in agreement that the causes of this shelf-fjord exchange should be studied well to understand the temperature variability near the glaciers to quantify the glacier melting. Many processes such as tides, local wind forcing, shelf fluctuations, freshwater supplies from rivers, underwater melting, and subglacial discharge (Straneo & Cenedese, 2015) are recognized as significantly controlling the shelf-fjord exchange. Apart from this, the density difference between the outside and interior of the fjord creates a pressure difference between the fjord and the shelf, resulting in baroclinic flows to the fjord. This process is also known as "baroclinic pumping".

In the history of shelf forcing starting in the 1980s, it was discovered that the density difference outside and the inside of the fjord creates a baroclinic change within the fjord. The baroclinic pumping was investigated further by running a numerical model. The dynamics of the shelf-fjord exchange in the Greenland fjord's response are the results of three non-dimensional variables (Jackson et al., 2018). According to [H. Jackson et al., 2018] They are 1) the fjord width over the deformation radius [W/Rd], 2) the forcing time scale over the fjord adjustment time scale, and 3) the forcing amplitude (shelf pycnocline displacements) over the upper layer thickness.

The West Spitsbergen Shelf (WSS) is a place where Atlantic, Arctic, and glacier waters exchange (Saloranta & Svendsen, 2001). Warm AW often intrudes on the fjord mainly through its subsurface. As a result, the west coast fjords of Spitsbergen undergo significant changes. Fundamental issues concerning what causes temperature and velocity variations near the Svalbard glacier remain unresolved. There are numerous studies taking place along Svalbard's west coast, although most of them are focused on Isforden. Isforden is one of the largest fjords on the west coast of Svalbard, Despite the fact that the Kongsfjorden-Krossfjorden system has a significant influence on the arctic climate system (Harms et al., 2007), we make an attempt to investigate the role of shelf forcing in driving Kongsfjorden circulation and transport between Kongsfjorden and WSS. One of the finest regions.

Eddy flux of Atlantic Water to the Eurasian Basin North of Svalbard.

M. Dolores Pérez-Hernández[1], Robert S. Pickart[2], Daniel J. Torres[2], Frank Bahr[2],Arild Sundfjord[3], Randi Ingvaldsen[4], Angelika H. H. Renner[4] and Vladimir Pavlov[3]

[1] Unidad Océano y Clima, Instituto de Oceanografía y Cambio Global, IOCAG, Universidad de Las Palmas de Gran Canaria, ULPGC, Unidad Asociada ULPGC-CSIC, Canary Islands, Spain
[2] Department of Physical Oceanography, Woods Hole Oceanographic Institution, Woods Hole, MA, USA.
[3] Norwegian Polar Institute, Tromsø, Norway.
[4] Institute of Marine Research, Tromsø, Norway.

ABSTRACT

The Svalbard branch of the Atlantic Water (AW) flows eastward north of Svalbard carrying warm and salty waters along the slope of the Arctic Eurasian Basin. Recent studies have shown that this current is baroclinically unstable and sheds eddies into the basin. Here we use data from a mooring array deployed near 30°E between September 2012 and September 2013 to explore the eddies shed from the boundary current. The instrument coverage extended down to 1200-m depth and meridionally to approximately 50 km offshore of the shelfbreak, which laterally bracketed the flow. The moorings contained conductivity-temperature-depth profilers that sampled the water column every 12 hours and acoustic Doppler current profilers that sampled the water column every hour. Eddies were present throughout the year and reached down to 600m depth, some of them embedded within the pycnocline. The study is carried out using two different methodologies to describe the eddies: an empirical orthogonal function analysis of the vertical sections of velocity, and case studies of eddy events in different seasons.

Atmospheric Blocking Disturbing the Transports through the Barents Sea Opening.

Finn Ole Heukamp[1], Lars Aue[1], Monica Ionita[1] and Torsten Kanzow[1, 2]

[1] Alfred-Wegener-Institute, Helmholtz Centre for Polar and Marine Research
[2] University of Bremen

ABSTRACT

The ocean transports though the Barents Sea Opening (BSO) are crucial for the fluxes of volume and heat between the Nordic Seas and the Arctic ocean. Atlantic Water that enters the Barents Sea, has major impact on the extent of winter sea ice and water mass properties downstream. Until 2000, the winter Atlantic Water transport through the BSO was dominantly controlled by the strength of the North Atlantic Oscillation (NAO). However, the high correlation between NAO and BSO transports broke down around the year 2000 for about 10 years before recovering afterward. In this period, two years with extraordinarly high volume transports in the westwards directed Bear Island Slope current at the northern edge of the BSO were found, largely affecting the transport balance in the BSO. The co-occurence of the breakdown of NAO control on the inflow and the extraordinary outflow events points toward a common forcing mechanism. In this study, we utilize various setups of the ocean and sea ice model FESOM2.1 to investigate the atmospheric forcing mechanisms responsible for the two years with the intensification of the Bear Island Slope current and draw a connection to the general loss of NAO control on the Atlantic Water transports. We find, that anomalous atmospheric blocking in the North Atlantic sector caused a deflection of transient cyclones, affecting both the Atlantic Water transport and the Bear Island Slope current in the BSO. In general, we aim at a better understanding of atmospheric processes that shape the transport variability in the BSO. As the Barents Sea is a major hotspot of climate change in the Arcitc, an improved knowledge of these processes is further cruicial for predicting the future of the Barents Sea and the Arctic in general.

Structure and seasonal variability of the Arctic Boundary Current north of Severnaya Zemlya.

Torsten Kanzow[1,2], Eugenio Ruiz-Castillo[1], Markus Janout[1], Jens Hölemann[1], Kirstin Schulz[3] and Vladimir Ivanov[4,5]

[1] Alfred-Wegener-Institut, Helmholtz-Zentrum für Polar- und Meeresforschung, Bremerhaven, Germany
[2] University of Bremen, Department of Physics and Electrical Engineering, Bremen, Germany
[3] University of Texas, Oden Institute for Computational Engineering and Sciences, Austin, TX, United States
[4] Lomonosov Moscow State University, Geography Faculty, Oceanology Department, Moscow, Russia
[5] Arctic and Antarctic Research Institute, St. Petersburg, Russia

ABSTRACT

We assessed the spatial and temporal variability of the Arctic Boundary Current (ABC) using 7 oceanographic moorings, deployed across the continental slope north of Severnaya Zemlya in 2015-2018. Transports and individual water masses were quantified based on temperature and salinity recorders and current profilers. Our results were compared with observations from the northeast Svalbard and the central Laptev Sea continental slopes to evaluate the hydrographic transformation along the ABC pathway. The highest velocities (>0.30 m s-1) of the ABC occurred at the upper continental slope and decreased offshore to below 0.03 m s-1 in the deep basin. The ABC showed seasonal variability with velocities two times higher in winter than in summer. Compared to upstream conditions in Svalbard, water mass distribution changed significantly within 20 km of the shelf edge due to mixing with- and intrusion of shelf waters. The ABC transported 4.2±0.1 Sv in the depth range 50-1000 m, where 0.55±0.06, 1.1±0.12, 0.75±0.15 and 0.8±0.12 Sv corresponded to Atlantic Water (AW), Dense Atlantic Water (DAW), Barents Sea Branch Water (BSBW) and Transformed Atlantic Water (TAW). 63-71% of transport was constrained to within 30-40 km of the shelf edge, and beyond 84 km, transport increases were estimated to be 0.5 Sv. Seasonality of TAW derived from local shelf-processes and advection of seasonal-variable Fram Strait waters, while BSBW transport variability was dominated by temperature changes with maximum transport coinciding with minimum temperatures. Further Barents Sea warming will likely reduce TAW and BSBW transport leading to warmer conditions along the ABC pathway.

ARCTIC OCEAN

Changes in the Atlantic Water circulation seen in CFC-12 and SF6 tracer ages in the central Arctic Ocean.

Wiebke Körtke[1], Maren Walter[1], Oliver Huhn[1] and Monika Rhein[1]

[1] Institute of Environmental Physics, University of Bremen, Germany

ABSTRACT

Atlantic Water is the major heat source for the Arctic Ocean. Under the impact of Arctic Amplification, the inflow and importance of Atlantic Water in the Arctic Ocean increases (Atlantification). The circulation patterns of the Atlantic Water within the Arctic Ocean are still not fully understood and variable under different phases of the Arctic Oscillation. Measurements of the trace gases Chlorofluorocarbon (CFC-12) and Sulfur hexafluoride (SF6) are used to calculate water mass ages to track ventilation processes and the circulation patterns of the Atlantic Water. In this study, we use CFC-12 and SF6 data along two transects in the central Arctic Ocean. Data are available for a positive (1994), a negative (2005), and a mixed phase (2015) of the Arctic Oscillation. The comparison of the tracer age pattern between 1994 and 2015 confirms a change in the Atlantic Water circulation towards a weaker/missing boundary current by ages approximately 10 years higher in 2015 and thus indicating a slower transport of the Atlantic Water. For 2015, a continuous inflow branch into the Canada Basin is suggested, with the Atlantic Water circulation crossing both transects. However, the tracer ages differ up to 10 years between the transects, indicating a discontinuity of this inflow. An impact of the Arctic Oscillation is also seen in the pathways of the Pacific Water in the hydrographic data.

21st Arctic-Subarctic Ocean Fluxes Workshop
10-12 May, 2023. Gran Canaria, Spain

Underwater Acoustics in a Spicy Arctic.

Francesca Pereira[1,2], Marilena Oltmanns[3], Robert Marsh[1], Gary Heald[2,4] and Timothy Clarke[2]

[1] School of Ocean and Earth Science, University of Southampton, Southampton, UK
[2] Defence Science and Technology Laboratory, Salisbury, UK
[3] National Oceanography Centre, Southampton, UK
[4] School of Engineering and Physical Sciences, Herriot Watt University, Edinburgh, UK

ABSTRACT

The Arctic has undergone rapid climate change over the last few decades, and its thermohaline structure is predicted to change drastically over the 21st century. Due to the dependency of sound speed on local temperature, salinity and pressure, changes to the thermohaline structure of the Arctic Ocean can have significant impacts on underwater acoustics. Density-compensated fluctuations in temperature and salinity, known as spice, can manifest in the form of finestructure thermohaline intrusions and spice fronts. This study seeks to quantify the impact of spice on both underwater sound speed and the variability of acoustic transmission loss, using observations of temperature and salinity collected in the Fram Strait during summer 2022. Isopycnal displacement was used to analyse depth and range-dependent variations in sound speed, enabling the separation of the effects of spice and internal waves. Spice is found to be the largest source of variability in sound speed particularly in the upper 100 m, and is found to cause sound speed anomalies of up to ±15 m s-1. These results suggest that the expected, drastic future changes in the Arctic thermohaline structure will have profound influences on underwater acoustics that must be considered in technological developments for ocean observations and, at the same time, provide new opportunities.

Sensitivity of Atmosphere-Ocean interactions to characteristics of the sea-ice edge, lead width and orientation, and model resolution.

Thomas Spengler[1] and Clemens Spensberger[1]

[1] Geophysical Institute, University of Bergen, and Bjerknes Center for Climate Research, Bergen, Norway

ABSTRACT

Cold air outbreaks play a crucial role in the air-sea heat exchange. Despite increasing model resolution, reliable forecasts of these events remain a challenge because of the vast range of scales and physical processes involved. Varying sea ice concentration and resolution in our idealized experiments alters the distribution and intensity of the air-sea heat exchange with ramifications for mixed layer depths in both the atmosphere and ocean. Furthermore, integrated and local sensible and latent heat fluxes depend on the model resolution as well as the distribution of the sea-ice concentration in the marginal ice zone. While surface sensible heat fluxes appear to be rather consistent across different model resolutions, surface latent heat fluxes respond to the organisation of convection at higher resolutions, a feature that is absent for coarser model grids.

Similarly to cold air outbreaks, modeling air-sea interactions through leads poses a major challenge due to of the vast range of scales and physical processes involved. Using idealised experiments with the WRF model, we investigate how the transformation of a cold air mass moving across lead-fractured sea ice depends on lead width and orientation, as well as model resolution. The extent to which leads are resolved strongly affects the overall air-sea heat exchange, with even the direction of the heat flux depending on model resolution. The dependence of the overall heat exchange on model resolution is strongly non-linear, with the worst representation of the heat exchange through leads occuring when these are just about to become resolved by the model grid. In addition, the orientation of the leads relative to the atmospheric flow affects the air-sea heat exchange. Heat exchange is least effective when the leads are oriented perpendicular to the atmospheric flow.

Regime shift in Arctic sea ice thickness distribution observed in Fram Strait.

Hiroshi Sumata[1], Laura de Steur[1], Dmitry Divine[1], Mats Granskog[1] and Sebastian Gerland[1]

[1] Norwegian Polar Institute

ABSTRACT

The Fram Strait Arctic Outflow observatory has been monitoring sea ice and ocean outflows at ~79°N for the last three decades. We examined changes of monthly mean sea ice thickness distributions obtained from upward looking sonars deployed in the observatory. We found that the thickness distributions can be reasonably approximated by lognormal functions except for fractions of very thin ice classes. We fitted the observed distributions with lognormal functions and used three parameters of the functions (modal thickness, modal peak height and variance) to describe the long-term changes of the thickness distribution. We found that these parameters exhibit a concurrent change and indicate a shift of the Arctic sea ice regime. The first regime is represented by a thick and deformed ice pack, described by thicker modal thickness with a smaller peak with larger variance of the distribution. The second regime has a thinner and more uniform ice cover, represented by thinner modal thickness with more compact distribution and smaller fraction of deformed ice. We examine residence time of sea ice in the Arctic basins that arrived in Fram Strait to explain the cause of the shift. Our analysis shows that shorter residence time in the last decade is responsible for the shift of the ice thickness distribution found in Fram Strait. We introduce a stochastic sea ice thickenning model which can explain the lognormal form of the ice thickness distributions and relation between the residence time of sea ice and ice thickness distribution.

Understanding the variability of the Eddy Kinetic Energy in the Arctic Ocean.

Camille Lique[1*], Heather Regan[1,2], Claude Talandier[1], Gianluca Meneghello[3] and Anne Marie Tréguier[1]

[1] LOPS, Brest, France
[2] NERSC, Bergen, Norway
[3] MIT, Cambridge, USA

[*]Online speaker

ABSTRACT

Mesoscale activity in the Arctic Ocean remains largely unexplored, owing primarily to the challenges of i) observing eddies in this ice-covered region and ii) modelling at such small deformation radius. In this talk, we will use results from a simulation performed with a high-resolution, eddy resolving model to investigate the spatial and temporal variations of the eddy kinetic energy (EKE) in the Arctic Basin, and compared it against the variations of the sea ice conditions. On average and in contrast to the typical open ocean conditions, the levels of mean and eddy kinetic energy are of the same order of magnitude, and EKE is intensified along the boundary and in the subsurface. On long time scales (interannual to decadal), EKE levels do not respond as expected to changes in the large scale circulation. This can be exemplified when looking at the spin up of the Beaufort gyre that occurred in response to a strong surface input of momentum in 2007-2008, that did not result into an increase in the EKE levels. On seasonal time scales, the estimation of a Lorenz energy cycle allows us to investigate the drivers behind the peculiarities of the EKE field, and to understand the relative roles played by the atmospheric forcing and sea ice for them.

Upper-ocean eddy dynamics in the Central Arctic during winter: an observational model-assisted reanalysis of the MOSAiC expedition.

Ivan Kuznetsov[1], Benjamin Rabe[1], Alexey Androsov[1], Ying-Chih Fang[2], Mario Hoppmann[1], Alejandra Quintanilla Zurita[1], Sven Harig[1], Sandra Tippenhauer[1], Kirstin Schulz[3], Volker Mohrholz[4], Ilker Fer[5], Vera Fofonova[1] and Markus Janout[1]

[1] Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany
[2] National Sun Yat-sen University University, 80424 Kaohsiung, Taiwan
[3] University of Texas at Austin, USA
[4] Leibniz-Institute for Baltic Sea Research Warnemuende, Germany
[5] Geophysical Institute, University of Bergen and Bjerknes Center for Climate Research, Bergen, Norway

ABSTRACT

This work presents an ocean reanalysis of the Multidisciplinary Observatory for the Study of Arctic Climate (MOSAiC) experiment. The observational data stems from a distributed network of autonomous ice-tethered buoys and a central observatory around the drifting ship. Nudging observational data provides an opportunity to reconstruct three-dimensional water properties and velocity by constraining a numerical model that resolves the dynamics of the (sub-)mesoscale. The model setup covers the region between 84.5 - 87.5 °N and 87.6 - 139.5 °E that the MOSAiC observatory crossed during Oct 2019 - Jan 2020.

We used the FESOM-C model, which is characterized by an unstructured mesh that is ideal to minimize the influence of boundary conditions on the area of interest. We set up the model with a varying horizontal resolution as fine as 250 meters resulting in 1.3 million horizontal nodes, and 240 sigma layers with a vertical resolution as fine as 1 meter. This enables us to resolve near-surface- and deep submesoscale processes. We developed a relatively simple nudging algorithm to utilize a large amount of data from different instruments and autonomous systems operated during MOSAiC. More than 630,000 single point temperature and salinity measurements and over 1000 vertical profiles were nudged by the model. Part of the observational data was not used for the nudging and serves to validate the model.

Overall the model can reproduce the lateral and vertical structure of the temperature, salinity, and density fields, which allows for projecting dynamically consistent features of these fields onto a regular grid. The simulation suggests the existence of two separate depth ranges of enhanced eddy kinetic energy, which are located around two maxima in the buoyancy frequency: the halocline depth and the depth of the warm water of Atlantic origin ("Atlantic Water"). The model resolves several warm and stationary Atlantic Water eddies and provides insights into the associated dynamics. Our study provides an approach to overcome the complications in the interpretation of observational data irregularly distributed in space and time.

Inverse estimates of volume, heat and freshwater fluxes in the Arctic gateways.

Hege-Beate Fredriksen[1,*], Takamasa Tsubouchi[2], Wilken-Jon von Appen[2], Torsten Kanzow[2], Laura de Steur[1] and Sheldon Bacon[3]

[1] Norwegian Polar Institute, Tromsø, Norway
[2] Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany
[3] National Oceanography Centre, Southampton, UK

[*]Fundación DISA supported Early Career Scientist

ABSTRACT

We quantify the overturning circulation in the Arctic Ocean, and associated heat transport (HT) and freshwater transport (FWT) across its boundaries. We present results in preparation by Tsubouchi et al. for the years 2004-2010, and our plans for extending these analyses after year 2010. The main data source consists of moored instrument records in the four Arctic main gateways: Davis Strait, Fram Strait, Bering Strait and the Barents Sea Opening. A box inverse model is employed to adjust the initial observations to obtain pan-Arctic scale mass and salt balanced velocity fields. The results from years 2004-2010 show that Atlantic Water is transformed into two different water masses in the Arctic Ocean at a rate of 4.0 Sv. Combined with 0.6 Sv Bering Strait inflow, 1.8 Sv flows back to the North Atlantic as the upper limb of overturning circulation, while 2.8 Sv returns southward as the lower limb of the overturning. The net ocean circulation and sea ice export through the four Arctic gateways amounts to a six-year mean influx of heat to the Arctic Ocean is 180±57 TW with an uncertainty of 20 TW and the export of FW is 156±91 mSv with an uncertainty of 61 mSv. The HT and FWT have large seasonalities ranging between 110-260 TW and 40-260 mSv, respectively. The obtained overturning circulation and associated HT and FWT transports presented here are vital information to better understand the Atlantic Meridional Overturning Circulation. For our future analyses, we discuss also how we can modify the conservation equations in the inverse model to account for storage of heat and freshwater in the Arctic Ocean.

Upper ocean turbulence and vertical mass fluxes from in-situ observations in the central Arctic Ocean 2015.

B. Rabe[1,*], M. Janout[1], Lars-Eric Heimbürger[2], Rob Middag[3], Ellen Damm[1], Sinhue Torres Valdes[1], Kirstin Schulz[4] and the PS94 shipboard scientific party

[1] Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung, Bremerhaven, Germany
[2] CNRS-MIO, France
[3] Royal Netherlands Institute for Sea Research (NIOZ), Netherlands
[4] University of Austin, Texas, USA

[*]Online speaker

ABSTRACT

The Arctic Ocean is generally assumed to be fairly quiescent when compared to many other oceans. The sea-ice cover, a strong halocline and a shallow, cold mixed-layer largely isolate exchange between the surface mixed-layer and the intermediate warm layer of Atlantic origin. The content of freshwater/salt and other dissolved substances differs strongly between these different layers. In order to understand changes in the highly-stratified upper Arctic Ocean and the sea-ice, including the ecosystem and ultimately, the atmosphere, it is crucial to quantify vertical mass and gas fluxes. Yet, direct flux measurements are difficult to obtain and, thus, sparse.

We present sets of under-ice turbulent microstructure profiles in the Eurasian and Makarov Basin of the Arctic Ocean from an expedition in 2015, that included complementary sampling with trace-metal-clean equipment. The period of sampling covers summer melt and autumn freeze-up across parts of the Eurasian and Makarov basins. Temporal averages of the profile measurements, spanning from 4 to 24 h, generally show elevated dissipation rates in each profile at the base of the mixed-layer, which was well-defined only from late August in the Amundsen and Makarov basins. In some of the profiles we observed a dual mixed-layer structure, suggesting subsequent mixing events or depth-dependent advective processes. In the underlying seasonal halocline turbulent eddy diffusivity largely defaulted to the molecular level, with few peaks in the lower halocline and the thermocline overlying the warm layer of Atlantic Water.

We will put vertical fluxes of dissolved salt, macro- and micronutrients, mercury, and methane in context with the seasonal variation in stratification, surface conditions and discuss implications for primary production.

High-resolution climate model suggests an increase in Arctic amplification and high-latitude marine extremes in the 21st century.

Ruijian Gou[1,2,*], Gerrit Lohmann[2,3] and Lixin Wu[1,4]

[1] Frontiers Science Center for Deep Ocean Multispheres and Earth System and Key Laboratory of Physical Oceanography, Ocean University of China, Qingdao, China
[2] Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Bremerhaven, Germany
[3] University of Bremen, Bremen, Germany
[4] Pilot National Laboratory for Marine Science and Technology (Qingdao), Qingdao, China.

[*]Online speaker

ABSTRACT

The Arctic is warming at a rate faster than any other oceans, a phenomenon known as Arctic amplification that has widespread impact on the global climate. In contrast, the Southern Ocean (SO) and Antarctica have been cooling over the past decades. The projection of these regions under global warming has a non-negligible model spread. Here we show that under a strong warming scenario from 1950 to 2100, comparing a cutting-edge high-resolution climate model to a low-resolution model version, the increase of Arctic amplification is 3 °C more and the SO and Antarctica warming is 2°C less. Previously ice-covered Arctic Ocean will exhibit greater SST variability under future global warming. This is due to an increased SST increase in summer due to sea ice retreat. Extreme warming events in the Arctic and SO, known as marine heat waves (MHW) that influence the ecology, are largely unknown. We find that the MHWs in the Arctic and SO are twice as strong in the high-resolution model version, where the increasing intensity of MHWs in the Arctic corresponds to strong decline (<-6% per decade) of sea ice. In both the high-resolution and low-resolution models, the duration of MHWs in the Arctic and SO shows a declining trend under global warming. The much stronger MHWs in the high-resolution model could be caused by two orders of magnitude more ocean turbulent energy. For example, the spatial patterns of SO MHW intensity correspond to the pattern of SO EKE. We conclude that the Arctic amplification and MHWs at high latitudes might be underestimated by the current generation of climate models with low resolution, and the SO and Antarctica warming might be overestimated. Our eddy- and storm-resolving model is expected to open new frontiers on how the system responds to human activities in a high CO2 world by evaluating the impact on past and future climate and environmental extremes.

Attribution of air-ice-sea interactions to cyclones, fronts, and cold-air outbreaks.

Clemens Spensberger*, Heather Regan, Guillaume Boutin, and Thomas Spengler

Geophysical Institute and Bjerknes Centre for Climate Reseach, University of Bergen

*Online speaker

ABSTRACT

Rapid changes in the sea ice cover are commonly attributed to periods of strong winds, which in turn are often associated with cyclones and their fronts. In addition to geographically redistributing sea ice, and thereby potentially increasing its export from the Arctic, cyclones also transport moist warm air masses into the Arctic, which can lead to local sea ice melt while the cyclone's cold sector might lead to freezing and sea ice formation. Analogously, the sign of the ocean-atmosphere heat exchange will depend on the location within the cyclone. Furthermore, cold air outbreaks associated with the withdrawal of cold air masses over the open ocean usually yield sea-ice formation. The relative contribution of these competing effects of weather events on the sea ice and ocean is so far poorly understood.

We climatologically assess these competing effects of cyclones on sea ice and ocean using detected cyclones, fronts, and cold-air outbreaks in the coupled ECMWF CERA-SAT reanalyses as well as in the state-of-the-art sea ice model neXtSIM which is coupled to NEMO and driven by ERA5. We decompose the climatological sea-ice increase and decrease during different seasons into the components that occur in the vicinity or at larger distance from the different weather events. The amplitude of both positive and negative sea ice changes increases around cyclones, with an overall net effect of reducing sea-ice concentration during all seasons. In contrast, cold-air outbreaks are always associated with sea-ice growth, but exhibit a clear seasonality in their frequency of occurrence. In general, however, only a small fraction of sea-ice concentration changes can be attributed to either cold-air outbreaks or cyclones for all seasons.

May 11th, Second day of talks.

Wind forcing of cross-slope transport in the Eurasian Arctic and implications for ocean circulation.

Francesca Doglioni[1], Claudia Wekerle[1], Sergey Danilov[1], Torsten Kanzow[1]

[1] Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung, Bremerhaven, Germany

ABSTRACT

Exceptional Arctic sea-ice retreat over the past decades has prompted new research on ocean-driven changes in sea ice, with great interest on possible impacts of changing pathways of warm and salty Atlantic water into the Arctic. Atlantic water enters the Arctic via a connected system of topographically steered slope currents, whose variability and drivers are to date not well understood. Recent advances in satellite altimetry for the ice-covered Arctic opened the possibility to study the variability of these large-scale circulation patterns up until the ice-covered regions, and link that to possible large-scale forcing mechanisms. In this work, we test this approach by investigating the seasonality in the Arctic slope currents system via state-of-the-art altimetry and model data.

We employed a recently published pan-Arctic gridded altimetry dataset (SAGA1, Doglioni et al., 20232) and a state-of-the-art coupled sea ice-ocean model (FESOM3, v1.4) to study the seasonal variability of the slope current system enclosing the Eurasian Arctic shelf seas. Altimetry and model data were compared to characterize the large-scale patterns of seasonal variability in sea surface height and slope currents, thereby validating the model. Model data were further used to investigate the forcing mechanisms of the observed seasonal variability.

SAGA and FESOM data provide a consistent picture of the seasonal variability, featuring shelf-wide sea surface height oscillations and associated wintertime acceleration of the slope currents. In agreement with previous studies, we find that these oscillations can be attributed to shelf mass variability, associated to wind patterns consistent with cross-slope Ekman transport. However, surface Ekman transport alone appears to be too large to directly explain this variability. We therefore considered vertical sections of cross-slope ocean transport to investigate how the transport at depth closes the ocean mass budget on the shelf. We observe that, in response to anomalous cross-slope Ekman transport, a compensatory flow anomaly develops below 50 m depth. This anomaly is mostly.

BERING STRAIT, CANADIAN ARCTIC

What's new in the Bering Strait?.

Rebecca Woodgate[1,*], Cecilia Peralta-Ferriz[1], and Laramie Jensen[1]

[1]University of Washington, Seattle, USA

[*]Online speaker

ABSTRACT

The Bering Strait is the only oceanic gateway between the Pacific and the Arctic oceans. The generally northward flow of waters through the strait brings heat, freshwater, and nutrients to the Chukchi Sea, the Arctic Ocean, and beyond. The oceanic heat through the strait is a trigger of Arctic sea-ice melt, and the Bering Strait heat flux is the best predictor found so far of Chukchi sea-ice retreat date. Being fresher than most Arctic waters, the Pacific waters entering through the strait provide strong upper ocean stratification in roughly half the area of the Arctic. The high nutrient content of these Pacific waters fuels highly productive ecosystems on the Chukchi shelf and provides a nutrient supply to the western Arctic.

Since 1990, year-round moorings have quantified the changing physical oceanic fluxes through the Bering Strait, showing long term flow increase, warming, and freshening, the latter being recently so dramatic as to possibly prevent ventilation of the Arctic's cold halocline layer. We report now on the most recent data and expedition, from summer 2022. These most recent annual means are very anomalous for recent years – they show an unusual cooling and salinification of the flow, with values comparable to the early 2000s, although the volume flux remains high. We report also on analysis of satellite data (Ocean Bottom Pressure and Dynamic Ocean Topography) which suggests the long-term trend in the flow is driven from the Arctic in summer and the Bering Sea in fall. Finally, we discuss new directions of nutrient and trace metal sampling in the strait, where preliminary results suggest the northward flux of some trace metals (iron and particularly manganese) through the strait rival or exceed the year-round net southward fluxes of metals between the Arctic and the North Atlantic.

21st Arctic-Subarctic Ocean Fluxes Workshop
10-12 May, 2023. Gran Canaria, Spain

Saildrone observed internal wave generation in seasonal ice-free Chukchi Sea shelf.

Nan-Hsun Chi[1,*], Dongxiao Zhang[1,2], Chidong Zhang[1]

[1] NOAA Pacific Marine Environmental Laboratory
[2] The Cooperative Institute for Climate, Ocean and Ecosystem Studies, University of Washington

[*]Fundación DISA supported Early Career Scientist

ABSTRACT

This study investigates the internal wave activities observed by saildrones in the eastern Chukchi Sea shelf during ice-free summer in 2019. The strong inertial currents (> 20 cm/s) in early July 2019 are driven by passage of an Arctic storm. The observed inertial wave activities are primarily a two-layer system as summer heating makes a sharp mixed layer. The horizontal scale of the observed internal wave events is about O(100 km). Our results suggest that the recent accelerated summer sea-ice retreat may lead to elevated internal wave activities and upper ocean mixing over the Chukchi shelf water, with ramification for ocean dynamics upstream Barrow Canyon, where much of the Pacific water drains into the interior Arctic.

21st Arctic-Subarctic Ocean Fluxes Workshop
10-12 May, 2023. Gran Canaria, Spain

Circulation timescales in the Canada Basin: Insights from transient tracers 129-iodine and 236-Uranium.

Annabel Payne[1,*], Anne-Marie Wefing[1], Nuria Casacuberta[1], Marcus Christl[1], John Smith[2] and Bill Williams[3]

[1] ETH Zurich, Switzerland
[2] Bedford Institute of Oceanography, Canada
[3] Institute of Ocean Sciences, Canada

[*] IASC supported early career scientist

ABSTRACT

Anthropogenic radionuclides iodine-129 and uranium-236 released from Nuclear Reprocessing Plants in Europe label Atlantic Water (AW) entering the Arctic Ocean and trace its pathways across the region to the Canada Basin. The time dependent releases of both nuclides to the marine environment allow estimates of transport times and degree of mixing using two different approaches for polar surface waters (if containing Atlantic signature) and waters in the Atlantic layer. The first consists of a binary mixing model, where tracer ages can be estimated when considering pure advective transport. The second is known as the transit time distribution (TTD) and accounts for tracer mixing along the flow field.

Here we present the first high-resolution study of the tracer labelled AW in the Canada Basin collected during the DFO JOIS 2020 monitoring program. This is the first in-depth study in this region using the combination of this dual tracer approach. Results show that tracer ages at the surface yield an estimated age range of 25 - 35 years, although with significant dilution, and are supported by TTD mode ages spanning from 15 to 32 years for the core of the AW layer. We find that within the AW, input concentrations of the tracers are conserved along the flow path, with minimal dilution, indicating a dominantly advective and stable flow, although there is lateral mixing within the AW layer itself. We also observe that there is significant spatial variation in the distribution of ages across the basin from North to South, which indicates two pathways of Atlantic waters into the Canada Basin: one going across the Chukchi Plateau and the other one around it. This study will be complemented with additional tracers taken in the Arctic Ocean in 2020 - 2022, to have a comprehensive quasi-synoptic view of pathways and timescales of circulation of AW in the Arctic Ocean.

Two decades of ocean observations in the Canadian Arctic Archipelago.

Clark Richards[1, 2,*], Shannon Nudds[1] and Lina Rotermund[2]

[1] Fisheries and Oceans Canada, Bedford Institute of Oceanography, Dartmouth NS Canada
[2] Dalhousie University, Department of Oceanography, Halifax NS Canada

[*] On-line speaker

ABSTRACT

The recently created Tallurutiup Imanga National Marine Conservation Area, encompassing Barrow Strait and the eastern portion of the Canadian Northwest Passage, is a major transport route for Arctic-derived freshwater to the North Atlantic ocean. Observations of ocean transports and properties were made across a section between Somerset Island and Devon Island, as part of the DFO/BIO Barrow Strait Monitoring Program, between 1998 and 2011. In 2017, a renewed DFO commitment to measuring ocean properties and transports in Tallurutiup Imanga lead to the redeployment of the monitoring program, which has provided a two-decade glimpse of ocean property changes in this crucial choke point. Here we present results from data acquired in recent campaigns, combined with the historical data, to elucidate trends and explore changes observed since the program inception.

Structure and variability of the Barrow Canyon outflow from two high-resolution shipboard surveys in 2018.

Jie Huang[1,*], Robert S. Pickart[1], Nicholas Foukal[1], Michael A. Spall[1], and Peigen Lin[1,2]

[1] Woods Hole Oceanographic Institution, Woods Hole, MA, USA
[2] School of Oceanography, Shanghai Jiao Tong University, Shanghai, China

[*] On-line speaker

ABSTRACT

Barrow Canyon in the northeast Chukchi Sea is a critical choke point where Pacific-origin water, heat, and nutrients enter the interior Arctic. While the flow through the canyon has been monitored for more than 20 years, questions remain regarding the dynamics by which the Pacific-origin water is fluxed offshore, as well as what drives the variability. In 2018, two high-resolution shipboard surveys of the canyon were carried out – one in summer and one in fall – to investigate the water mass distribution and velocity structure of the outflow. During the summer survey, high percentages of Pacific water (summer water + winter water) were present seaward of the canyon, associated with strong northward outflow from the canyon and a well-developed westward-flowing Chukchi Slope Current (CSC). By contrast, high percentages of Pacific water were confined to the canyon proper and outer Chukchi shelf during the late-fall survey, at which time the canyon outflow and CSC were considerably weaker. These differences can be attributed to differences in wind forcing during the time period of two surveys. A cyclone-like circulation was present in the canyon during both surveys, which was also evident in the satellite-derived sea surface anomaly field. We argue that this feature corresponds to an arrested topographic Rossby wave, generated as the outflow responds to the deepening bathymetry of the canyon. By applying a self-organization map analysis using the satellite altimeter data from 2001-2020, we demonstrate that such a cyclone-like structure is a prevailing aspect of the canyon outflow.

On the release of freshwater from the Beaufort Gyre.

Qiang Wang*

Alfred Wegener Institute, Germany

* On-line speaker

ABSTRACT

In this study the sensitivity of freshwater release from the Beaufort Gyre to wind forcing is investigated using numerical simulations. The purpose is to understand how different wind forcing can influence the release of freshwater from the Beaufort Gyre and the gateways through which the freshwater leaves the Arctic Ocean to the North Atlantic. Both the impacts of the locations of cyclonic winds in the Arctic and the sea level drop in the subpolar gyre are explored. The freshwater release from the Beaufort Gyre and from the whole Arctic Ocean is compared.

FRAM STRAIT OUTFLOW, EGC AND EG SHELF

Atmospheric Forcing and Oceanic Response of the Northeast Water Polynya.

Miriam Bennett[1,*], Ian Renfrew[1] and David Stevens[1]

[1]University of East Anglia, UK.

[*] IASC supported Early Career Scientist

ABSTRACT

The Northeast Water polynya is a significant annually recurring Arctic polynya located off the coast of Northeast Greenland. It is important for marine wildlife and influences local atmospheric and oceanic processes. In this study we analyse 43 years of observational and reanalysis products to characterise its climatology and show that it has more spatiotemporal variability than previously thought. We conclude that the variability is largely driven by atmospheric forcing such that the polynya extent is determined by the direction of the near-surface flow regime. The surface conditions also appear to impact the water column in this region, with a strong seasonal cycle reflected in the potential temperature and ocean salinity reanalysis products, for which the influence of the sea ice decreases with depth. Analysis of these products shows a long-term trend of freshening near the surface and salinification at approximately 200 m, and a significant warming trend at all depths. As the Arctic region changes due to anthropogenic forcing, the sea ice edge is migrating northwards and the Northeast Water polynya is generally opening earlier and closing later in the year, suggesting a future transition to a large marginal ice zone with reduced annual variability, which could have significant implications for the ocean in this complex and quickly changing environment.

Three Forcing Mechanisms of Freshwater Transport in Fram Strait.

Karpouzoglou, T.[1,3,*], De Steur, L.[1], Sumata, H.[1], Karcher, M.[2] and Smedsrud, L. H.[3]

[1] Norwegian Polar Institute
[2] Alfred Wegener Institute
[3] University of Bergen

[*] IASC supported Early Career Scientist

ABSTRACT

We analyse time series from the moorings in the western Fram Strait between 2003 and 2020 and investigate the variability of the liquid freshwater transport (FWT, reference salinity 34.9), volume transport and freshwater content. We examine composites and correlations of the time series with sea-level pressure (SLP) reanalysis, and remote-sensing dynamic-ocean topography (DOT) data in the Arctic Ocean. We identify three forcing mechanisms of FWT: I) With 13 to 24 months lead, high SLP anomalies drive ocean convergence in the Eurasian sector freshening the repositories north of the Fram Strait. II) With 0 to 9 months lead, low SLP anomalies drive ocean divergence centred in the Canada Basin directing fresh water to the margins of the ocean and to Fram Strait. III) Low SLP anomalies in the Barents Sea and the induced northerlies over Fram Strait confine fresh water to the Greenland shelve, driving strong baroclinic volume transport. Additionally, we find that the total volume transport (VTtot) experiences a negative trend of 0.1 Sv/year, in association with weakening northerlies, and reducing north-south DOT gradient across the strait. The first follows the decreasing SLP over Greenland due to warming, and the second a halo/thermosteric expansion of the Nordic Seas. Finally, we discuss a possible "teleconnection" between Fram Strait and the Beaufort Gyre through concurrent wind forcing, and show that winter averages of the Arctic Oscillation correlate positively with VTtot (R=0.55), but in association to mechanism I, correlate negatively with FWT (R=-0.64) with one year lag.

Shifts of the Recirculation Pathways in Fram Strait drive Atlantic Water Variability on Northeast Greenland shelf.

Rebecca McPherson[1], Claudia Wekerle[1] and Torsten Kanzow[1,2]

[1] Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Bremerhaven, Germany
[2] University of Bremen, Bremen, Germany

ABSTRACT

During the last two decades, rising ocean temperatures have significantly contributed to accelerated mass loss of the Greenland Ice Sheet. Warming subsurface Atlantic Intermediate Water (AIW) found on the wide continental shelf of Northeast Greenland (NEG) interacts with marine-terminating glaciers and causes their rapid melting and retreat. The variability of the AIW on the NEG shelf is investigated using historical hydrographic observations and high-resolution numerical simulations with the Finite-Element-Sea ice-Model (FESOM2). There is good spatio-temporal agreement between the model and observations at both local and regional scales.

Warm AIW moves towards the glaciers through the deep trough system on the NEG continental shelf as a bottom intensified jet. The AIW features both pronounced interannual fluctuations and a long-term warming trend. A major source of AIW on the NEG shelf is warm Atlantic Water (AW) originating from the West Spitzbergen Current that recirculates in the Fram Strait. AW anomalies are advected westwards and control part of the AIW variability on the NEG shelf. Increased interannual AIW temperatures on the shelf are also connected to a change in the regional circulation pattern and enhanced AW temperatures. A northwards shift of the AW pathways allows more and warmer AIW to flow onto the northern part of the NEG shelf. There, it circulates anti-cyclonically and results in shelf-wide warming. The shift in recirculating AW is likely driven by anticyclonic wind anomalies over the Barents Sea, which force enhanced northwards AW transport in Fram Strait. Controlled by a combination of upstream conditions, the AIW temperature variability on the NEG shelf may also impact the heat transport reaching the Arctic Ocean.

High-resolution simulation of the ocean circulation beneath the 79°North Glacier in North East Greenland.

Claudia Wekerle[1,*], Sergey Danilov[1], Torsten Kanzow[1], Rebecca McPherson[1], Patrick Scholz[1], Ralph Timmerman[1] and Qiang Wang[1]

[1]Alfred-Wegener-Institute, Germany

[*]Online Speaker

ABSTRACT

During the last two decades, the Greenland Ice Sheet has been losing mass at an accelerating rate. Freshwater fluxes from the ice sheet have implications for the global sea level, and can affect the strength of the Atlantic Meridional Overturning Circulation. The mass loss has been attributed to both atmospheric warming and enhanced submarine melting at marine-terminating glaciers. The largest marine-terminating glaciers in Northeast Greenland (NEG) are the 79°North Glacier (79NG) and the Zachariæ Isstrøm (ZI), which drain the Northeast Greenland Ice Stream.

Despite their importance for the regional ocean circulation, the cavities of these glaciers are not resolved in state-of-the-art ocean models. Here we present a global simulation with the Finite-volumE Sea ice-Ocean Model (FESOM2.1), which explicitly resolves the ice shelf cavities of the 79NG and ZI. Mesh resolution in the vicinity of the cavities was set to 700 m, which allows to resolve the complex bathymetry in the area. A decadal-long hindcast simulation (1960-2021) revealed the interannual variability of basal melt rates. We found that it is mainly the warm and dense Atlantic Intermediate Water, present on the NEG continental shelf year-round, which is responsible for the variability of basal melt rates. Moreover, we released passive tracers in the model which trace basal melt water and subglacial discharge. These tracer experiments show how the freshwater released from the NEG glaciers interacts with the regional ocean circulation, and how it contributes to the freshwater outflow from the Arctic Ocean.

NORDIC SEAS AND ICELAND

Distribution of copper-binding ligands in Fram Strait and influences from the Greenland Shelf.

Veronica Arnone[1], J. Magdalena Santana-Casiano[1], Melchor González-Dávila[1], Geraldine Sarthou[2], Stephan Krisch[3], Pablo Lodeiro[4], Eric P. Achterberg[3] and Aridane G. González, [1]

[1] Instituto de Oceanografía y Cambio Global, IOCAG, Universidad de Las Palmas de Gran Canaria, ULPGC, Spain.
[2] Univ Brest, CNRS, IRD, Ifremer, LEMAR, F-29280 Plouzane, France.
[3] GEOMAR Helmholtz Centre for Ocean Research Kiel, 24148 Kiel, Germany.
[4] Department of Chemistry, University of Lleida – AGROTECNIO-CERCA Center, Rovira Roure 191, 25198, Lleida, Spain.

ABSTRACT

The Fram Strait represents the major gateway of Arctic Ocean waters toward the Nordic Seas and North Atlantic Ocean and is a key region to study the impact of climate change on biogeochemical cycles. In the region, information about trace metal speciation, such as copper, is scarce. This manuscript presents the concentrations and conditional stability constants of copper-binding ligands (LCu and log KcondCu2+L), estimated by Competitive Ligand Exchange-Adsorptive Cathodic Stripping Voltammetry (CLE-ACSV), from the water column of Fram Strait and the Greenland shelf (GEOTRACES cruise GN05). Based on water masses and the hydrodynamic influences, three provinces were considered (coast, shelf, and Fram Strait) and differences were observed. The strongest variability was detected in surface waters, with increasing LCu concentrations (mean values: Fram Strait=2.55±1.03 nM; shelf=5.23±1.25 nM; coast= 6.36±0.77 nM) and decreasing log KcondCu2+L values (mean values: Fram Strait=15.56±0.31; shelf=15.17±0.29; coast=14.81±0.27) toward the west. The surface LCu concentrations obtained above the Greenland shelf indicate a ligand supply from the coastal environment to the Polar Surface Water (PSW) which is an addition to the ligand exported from the Central Arctic to the Fram Strait. Several processes were suggested to explain the LCu and log KcondCu2+L differences observed between shelf and coastal samples, such as biological activity in sea-ice, phytoplankton bloom in surface waters, bacterial degradation, and meltwater discharge from 79NG glacier terminus. Overall, the ligand concentration exceeds those of dissolved Cu (dCu), maintaining free copper (Cu2+) at non-toxic concentrations (0.13 - 21.13 fM) and stabilising dCu in surface waters, which favoured its transport to the Nordic Seas and the microorganism's development.

21st Arctic-Subarctic Ocean Fluxes Workshop
10-12 May, 2023. Gran Canaria, Spain

A 70-year perspective on convection in the Greenland Sea.

Anna-Marie Strehl[1], Kjetil Våge[1] and Lars Henrik Smedsrud[1,2]

[1] University of Bergen and Bjerknes Center for Climate Research
[2] University of Svalbard

ABSTRACT

The Greenland Sea was known as a place for bottom-reaching convection, but since the mid-1980s only intermediate convection has been inferred from observations. Due to this change, the Greenland Sea turned from a source of deep water that was too dense to flow across the Greenland-Scotland Ridge to a source of overflow water and therefore became a contributor to the Atlantic Meridional Overturning Circulation (AMOC). Based on observations that cover the period from 1950 to 2020, we identified a substantial temperature increase as the main reason for the cessation of bottom-reaching convection, which eventually led to the separation of the water column into deep and intermediate water masses. Since Greenland Sea Deep Water has been decoupled from the surface, its properties converged with the properties of the deep ocean basins in the vicinity. Increased heat fluxes in the late 1990s could not balance the warming trend but supported the formation process of Greenland Sea Arctic Intermediate Water.

Recent weakening of the open ocean convection in the Greenland Sea.

Lucas Almeida[1,*], Nicolas Kolodziejczyk[1] and Camille Lique[1]

[1]Univ. Brest, CNRS, IRD, Ifremer, Laboratoire d'Océanographie Physique et Spatiale, IUEM, France

[*]Fundación DISA supported Early Career Scientist

ABSTRACT

Ocean convection is responsible for ventilating the deep layers of the ocean. This process thus plays an important role in the climate system as a source of the lower limb of the Atlantic Meridional Overturning Circulation (AMOC). The Greenland Sea is one of the few locations where deep ocean convection is intense, with a large variability that has gone through periods of shutdowns or strong activity. There is an extensive literature documenting periods of intense convection up to 2016. Here, we extend for the first time, the analysis to 2020 using ISAS, an optimal interpolation product based on ARGO data. We found that a dramatic reduction, no deeper than 500m depth, in deep convection occurred in 2014 in the center of the Greenland Sea and has persisted until at least 2020. This shutdown of deep convection may be explained by unabated warming within the mixed layer, although a new freshening trend after 2014. There is a strong correlation between temperature and salinity in the top 500 m during the months preceding convection (September-December) with the mixed layer depth in the late winter (February-April), suggesting that preconditioning is the main driver to allow for or inhibit the development of deep convection. We suggest that the changes in the density of the upper water column of the Greenland Sea are due to large-scale atmospheric forcing, particularly the sea level pressure (SLP) and wind stress curl, which affects the pathway of waters exported to the Nordic Seas. A deep convection shutdown in the Greenland Sea would impact the properties of the deep waters in the North Atlantic region and weaken the AMOC transport.

Dense-water formation in the northwestern Iceland Sea

Stefanie Semper[1,2,3], Kjetil Våge[1,2], Silje Skjelsvik[4], Linda Latuta[5] and Ilker Fer[1,2]

[1] University of Bergen, Norway
[2] Bjerknes Centre for Climate Research, Bergen, Norway
[3] Woods Hole Oceanographic Institution, Woods Hole, USA
[4] University of Bergen, Norway; now at Sweco, Bergen, Norway
[5] Technical University of Denmark; now at University of Bergen, Norway

ABSTRACT

Dense waters formed in the Nordic Seas supply the lower limb of the Atlantic Meridional Overturning Circulation. Using a unique, two-year long moored record from the northwestern Iceland Sea, we provide evidence of the formation of dense water that exceeded the limit of overflow water in both winters. The locally formed water in the northwestern Iceland Sea at present attained densities similar to those of water formed in the central Iceland Sea several decades ago. This shift in the locus of dense-water formation from the interior basin to the western Iceland Sea is associated with the retreat of the sea-ice edge toward Greenland, which determines the location of the highest turbulent heat fluxes in the area. In particular, the ocean mixed layer at the mooring site cooled and deepened as an integrated response to a succession of cold-air outbreaks, which accounted for 54% and 40% of the wintertime heat loss in the winter 2016/2017 and winter 2017/2018, respectively. In the first winter, a maximum mixed-layer depth of approximately 450 m was reached, compared to only 350 m in the second winter. This pronounced difference can be attributed to greater turbulent heat fluxes and a more even distribution of cold-air outbreaks in the first winter.

Enhanced zooplankton biomass in the bathypelagic zone of the Subarctic Ocean.

Santiago Hernández-León[1]

Instituto de Oceanografía y Cambio Global, IOCAG, Universidad de Las Palmas de Gran Canaria, Unidad Asociada ULPGC-CSIC, Campus de Taliarte, 35214 Telde, Gran Canaria, Canary Islands, Spain.

ABSTRACT

Sequestration, in contrast to export, is a mechanism of the biological pump in the ocean occurring when carbon cannot return to the atmosphere in at least 100 years, normally the carbon transported below 1000 m depth. Thus, the study of bathypelagic carbon flux is of paramount importance to understand the ocean drawdown carbon transport. Here, we review bathypelagic zooplankton biomass along a wide range of latitudes including the Arctic and Subarctic Atlantic Ocean. We observed bathypelagic zooplankton biomass to match the gradient of phytoplankton biomass in shallower layers, suggesting that an increase in productivity in the upper layers promote an increase of zooplankton in the bathypelagic zone. This match would indicate a shunt of energy and matter from the upper layers of the ocean, promoting carbon sequestration. This observation is of paramount interest to account for the role of the ocean in buffering climate change and provides evidence of an important role of the pelagic fauna to sequester carbon in high latitudes of the ocean.

Insights into the fate of Arctic derived dissolved organic matter in a subarctic sea.

Caroline Gjelstrup [1] and Colin Stedmon[1]

[1]National Institute for Aquatic Resources, Technical University of Denmark, 2800 Lyngby, Denmark

ABSTRACT

The Arctic Ocean receives a disproportionate amount dissolved organic matter (DOM) relative to its size due to a large riverine contribution. This DOM contribution is expected to increase as climate change enhances permafrost thaw and accelerates the hydrological cycle, questioning the future role of the Arctic in the global carbon cycle, yet the fate of Arctic DOM is not well understood in the present day.

Over the two past decades, DOM has emerged as a promising tracer of Arctic waters, providing insights into the origins, distribution and transformation of freshwater and carbon in the central Arctic Ocean. In this study, we expand on this approach and explore the utility of DOM as a tracer downstream of the central Arctic Ocean in the Baffin Bay and Labrador Sea. A combination of discrete water samples and in-situ profiles collected along five sections in October 2022 were analysed to assess biogeochemical connectivity across the Arctic – subarctic boundary and quantify the oceanic fate of terrestrially derived Arctic carbon.

We find that despite severe dilution and mixing with ambient water masses, the DOM characteristics unique to Arctic waters persists across the Arctic – sub-Arctic boundary and can be traced from Fram Strait, via the East and West Greenland Currents and into the Labrador Sea. Similarly, Arctic halocline waters exported via the Canadian Arctic Archipelago have a distinct DOM signal, which extends throughout the western part of Baffin Bay. The two Arctic outflows are distinct from one another in terms of their chemical characteristics making it possible to separate their respective freshwater and carbon contributions through Davis Strait. The observations presented here demonstrate biogeochemical connectivity at large regional scales and provide insights into the transport and fate of Arctic DOM.

May 12th, Last day of talks.

Coupled atmosphere–ocean observations of a cold-air outbreak and its impact on the Iceland Sea.

Ian A. Renfrew[1], Jie Huang[2], Stefanie Sempe[2,3], Christopher Barrell[1], Annick Terpstra[1,3] Robert S. Pickart[2], Kjetil Våge[3], Andrew D. Elvidge[1], Thomas Spengler[3], Anna-Marie Strehl[3] and Alexandra Weiss[4]

[1] School of Environmental Sciences, University of East Anglia, Norwich, UK
[2] Woods Hole Oceanographic Institution, Woods Hole, Massachusetts USA
[3] Geophysical Institute, University of Bergen and Bjerknes Centre for Climate Research, Bergen, Norway
[4] British Antarctic Survey, Cambridge, UK

ABSTRACT

Marine cold-air outbreaks (CAOs) are vigorous equatorward excursions of cold air over the ocean, responsible for the majority of wintertime oceanic heat loss from the subpolar seas of the North Atlantic. However, the impact of individual CAO events on the ocean is poorly understood. Here we present the first coupled observations of the atmosphere and ocean during a wintertime CAO event, between 28 February and 13 March 2018, in the subpolar North Atlantic region.

Comprehensive observations are presented from five aircraft flights, a research vessel, a meteorological buoy, a subsurface mooring, an ocean glider, and an Argo float. The CAO event starts abruptly with substantial changes in temperature, humidity and wind throughout the atmospheric boundary layer. The CAO is well mixed vertically and, away from the sea-ice edge, relatively homogeneous spatially. During the CAO peak, higher sensible heat fluxes occupy at least the lowest 200m of the atmospheric boundary layer, while higher latent heat fluxes are confined to the surface layer. The response of the ocean to the CAO is spatially dependent. In the interior of the Iceland Sea the mixed layer cools, while in the boundary current region itwarms. In both locations, the mixed layer deepens and becomes more saline. Combining our observations with one-dimensional mixed-layer modelling, we show that in the interior of the Iceland Sea, atmospheric forcing dominates the ocean response. In contrast, in the boundary current region lateral advection and mixing counteract the short-term impact of the atmospheric forcing. Time series observations of the late-winter period illustrate a highly variable ocean mixed layer, with lateral advection and mixing often masking the ocean's general cooling and deepening response to individual CAO events.

Surface-forced variability in Nordic Seas overturning circulation and overflows.

Marius Årthun[1,*]

[1]Geophysical Institute, University of Bergen, and Bjerknes Centre for Climate Research, Bergen, Norway

[*]On-line speaker

ABSTRACT

Water mass transformation in the Nordic Seas and the associated overflow of dense waters across the Greenland-Scotland Ridge (GSR) acts to maintain the lower limb of the Atlantic meridional overturning circulation (AMOC). Here, we use ocean and atmospheric reanalyses to assess the temporal variability in the Nordic Seas overturning circulation between 1950 and 2020 and its relation to surface buoyancy forcing. We find that variable surface-forced transformation of Atlantic waters in the eastern Nordic Seas can explain variations in overflow transport across the GSR. The production of dense water masses in the Greenland and Iceland Seas is of minor importance to overflow variability. The Nordic Seas overturning circulation shows pronounced multidecadal variability that is in phase with the Atlantic Multidecadal Variability (AMV) index, but no long-term trend. As the AMV is currently transitioning into its negative phase, the next decades could see a decreased overflow from the Nordic Seas. CMIP5 and CMIP6 models support a weakened Nordic Seas overturning circulation toward 2040, but with a subsequent strengthening toward 2100.

Impact of large-scale ocean circulations on heat content variability in the Lofoten Basin.

Sourav Chatterjee[1,*], Roshin P Raj[2] and Antonio Bonaduce[2]

[1] National Centre for Polar and Ocean Research, Ministry of Earth Sciences, India
[2] Nansen Environmental and Remote Sensing Center and Bjerknes Center for Climate Research, Bergen, Norway

[*]On-line speaker

ABSTRACT

In this presentation, we will show the results obtained from TOPAZ4b ocean re-analysis focusing on the upper ocean (700m) heat content variability in the Lofoten Basin (LB). Although previous studies have confirmed a significant role of air-sea heat fluxes in regulating heat content variability (particularly during winter), the role of large-scale ocean circulation is not well explored. The two major features of large-scale oceanic circulations around the LB are the baroclinic front current and the barotropic cyclonic gyre circulation. The gyre circulation strongly responds to wind forcing and shows a significant seasonality, with the weakest (strongest) circulation strength in summer (winter). Decomposing the LB upper ocean heat storage rate into contributions from air-sea heat flux and oceanic heat advection, we show that, while the air-sea heat flux strongly dictates the high frequency (monthly) variability of heat storage rate, the oceanic heat advection has a comparatively larger role on the low frequency (interannual) variability. Moreover, in the absence of heat loss to the atmosphere during summer, the role of oceanic heat advection becomes most dominant. We then show that a significant amount of this oceanic heat advection can be modulated by the strength of the gyre circulation in the LB. We propose that interaction between the baroclinic front current and the mean barotropic gyre circulation plays an important role in advecting and storing warmer Atlantic Water into the basin.

Slantwise Convection in the West Greenland Current.

Ruiqi Shu[1,*], Ruijian Gou[2, 3], Clark Pennelly[3] and Paul G. Myers[3]

[1] Chongben Honors College, Ocean University of China, Qingdao, China
[2] Key Laboratory of Physical Oceanography and Frontiers Science Center for Deep Ocean Multispheres and Earth System, Ocean University of China, Qingdao, China
[3] Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, Alberta, Canada

[*]On-line speaker

ABSTRACT

Deep convection occurs in the Labrador Sea during the winter with strong atmospheric forcing, producing dense Labrador Sea Water (LSW) that feeds the lower limb of the Atlantic Meridional Overturning Circulation (AMOC). This deep convection is significantly influenced by the boundary current circulation of freshwater in the Labrador Sea, particularly the West Greenland Current (WGC) system. According to previous surveys, the WGC is the major route for freshwater to enter the interior of the Labrador Sea through the eddy formation. In this study, we emphasize the significance of wind forcing on the WGC and its effects on vertical mixing and eddy generation. When the southerly wind blows along the WGC, the wind-induced Ekman transport pushes denser water over lighter water, bringing a positive buoyancy flux, which triggers symmetric instability and slantwise convection. We found evidence of slantwise convection in the WGC by examining the output of a very high-resolution model (LAB60) and an idealized model. We further argued that the influence of this slantwise convection can reach 200 to 300m, which is roughly 3-4 times of the conventionally defined mixed layer depth. Additionally, we discovered that the symmetric instability cannot be ignored in the WGC comparing with previously assumed baroclinic and barotropic instability by evaluating the budget of eddy kinetic energy (EKE), which may have a considerable impact on the eddy formation along WGC.

The role of ocean circulation and associated changes in ocean heat transport in affecting the climate in Iceland.

Steingrímur Jónsson[1]

[1]University of Akureyri and Marine and Freshwater Research Institute, Borgir v/Norðurslóð, 600 Akureyri, Iceland

ABSTRACT

Iceland enjoys a much warmer climate than the average for its latitude. A major reason for this is the warm ocean currents in the Atlantic south of Iceland. There is a large heat flux from the ocean to the atmosphere and the air temperature therefore depends to a high degree on the ocean temperature. During the last roughly two decades, glaciers in Iceland have generally been retreating as well as having a negative mass balance due to a warmer climate, whereas during three decades prior to that, most of the glaciers in Iceland were advancing. The air temperature in Iceland south of the largest Icelandic glacier, Vatnajökull, showed a rise in temperature of about 1°C from 1995 to the early 2000’s and since then it has mostly remained at this high level. Often this warmer climate is attributed entirely to global warming. However, the temperature in the warm and saline Atlantic water south of Iceland also increased by about 1°C during the same period. This rise in ocean temperature was accompanied by an increase in salinity which indicates that the temperature rise was mostly due to a change in the ocean circulation, resulting in advection of warmer and saltier water to the area. In the period from 1995 to the early 2000’s the ocean heat flux with the Atlantic water across the Greenland-Scotland ridge increased by 21 TW, partly through Denmark Strait towards the continental shelf north of Iceland. The increased heat flux was attributed to a rising temperature as well as increased flow of Atlantic water. Only about 0.1 TW is needed to explain the recent melting of Icelandic glaciers. With a relatively sudden 1°C rise in temperature the glaciers will take decades to reach equilibrium with this new temperature and if the temperature does not decrease, the glaciers will continue to lose mass. There are records of advancing and retreating Icelandic glaciers from 1930 and they show a good correspondence with the Atlantic Multidecadal Oscillation (AMO), that reflects temperature variations in the North Atlantic Ocean.

AROUND GREENLAND TO DAVIS STRAIT AND THE LABRADOR SEA

Freshwater Exchange Between the Arctic and Sub-Polar North Atlantic.

Paul G. Myers[1], Clark Pennelly[1], Ruijian Gou[1], Yarisbel-Garcia Quintana[1], Pouneh Hoshyar[1] and Tahya Weiss-Gibbons[1]

[1]Department of Earth and Atmospheric Sciences, University of Alberta

ABSTRACT

Large and rapid temperature changes are occurring presently in the Arctic. The Arctic Ocean is already undergoing rapid loss and thinning of sea-ice that combined with enhanced freshwater input is leading to significant changes in circulation and enhanced regional freshwater storage. The Arctic Ocean exports significant amounts of acidic, low-salinity water to the Atlantic Ocean, although there is also return flow of warmer and saltier Atlantic water to polar regions. This Arctic Ocean export involves two routes, along the east and west side of Greenland, that eventually feed the Labrador Sea. West of Greenland, the Arctic export travels through the narrow and complicated channels of the Canadian Arctic Archipelago (CAA). Significant mixing occurs in the channels of the CAA, meaning this region is not just a conduit, but also plays a key role in transforming through flowing waters, as well as impacting the transit timescale through storage. In Baffin Bay, the local basin circulation is both impacted by, and links, Arctic and Atlantic waters inflowing to the basin, with discharge from the Greenland ice sheet. In this presentation, we study freshwater process and gateway transports from the Arctic Ocean to the Sub-Polar North Atlantic using the Arctic and Northern Hemisphere Atlantic (ANHA) regional configuration of NEMO. We consider model resolutions that range from ¼ degree to 1/60 degree and consider explicitly the role of tidal forcing in mixing and freshwater processes.

An updated observational record of Davis Strait ocean transports, 2004-2017.

Jed Lenetsky[1], Craig M. Lee[2], Clark Richards[3] and Alexandra Jahn[1]

[1] University of Colorado - Boulder and Institute of Arctic and Alpine Research
[2] Applied Physics Lab, University of Washington
[3] Bedford Institute of Oceanography

ABSTRACT

The Davis Strait, located in Southern Baffin Bay between Greenland and the Canadian Arctic Archipelago, is a key gateway of oceanic exchange between the Arctic and North Atlantic Oceans. Large fluxes of fresh Arctic Waters through the Davis Strait potentially influence deep-water formation in the Labrador Sea, with implications for the strength of the Atlantic Meridional Overturning Circulation. From 2004-2017, and 2020-present, ocean temperatures, salinities, and velocities have been measured along a moored array spanning the entire strait, allowing for ocean transports to be assessed over both the continental shelves and central channel. Here we will present new data from 2011-2017, extending the previously published data for 2004-2010. Furthermore, the whole record has been updated, filling spatial and short temporal data gaps using average temperature, salinity, and velocity sections from high resolution Seaglider surveys from 2004 to 2014. These updated volume, freshwater, and watermass transports will increase understanding of changing oceanic conditions in Baffin Bay, as well as local and remote physical mechanisms that govern the Davis Strait throughflow on synoptic to interannual timescales.

Cessation of Labrador Sea Convection by Freshening through (Sub)mesoscale Flows.

L. Clement[1], E. Frajka-Williams[2], N. von Oppeln-Bronikowski[3], I. Goszczko[4] and B. de Young[3]

[1] National Oceanography Centre, Southampton, UK
[2] University of Hamburg, Hamburg, Germany
[3] Memorial University, St John's, Canada
[4] Institute of Oceanology PAN, Sopot, Poland

ABSTRACT

By ventilating the deep ocean, deep convection in the Labrador Sea plays a crucial role in the climate system. Unfortunately, the mechanisms leading to the cessation of convection and, hence, the mechanisms by which a changing climate might affect deep convection remain unclear. In winter 2020, three autonomous underwater gliders sampled the convective region and both its spatial and temporal boundaries. Both boundaries are characterised by higher sub-daily mixed-layer depth variability than the convective region. At the convection boundaries, buoyant intrusions--including eddies and filaments--primarily drive restratification by bringing freshwater, instead of warm warmer, and instead of atmospheric warming. At the edges of these intrusions, submesoscale instabilities, such as symmetric instabilities and mixed-layer baroclinic instabilities, seem to contribute to the decay of the intrusions. In winter, strong destabilising surface heat flux and along-front winds can enhance the lateral stratification, sustaining submesoscale instabilities. Consequently, winter atmospheric conditions and freshwater intrusions participate in halting convection by adding buoyant freshwater into the convective region through submesoscale flows. This study reveals freshwater anomalies in a narrow area offshore of the Labrador Current and near the convective region; this area has received less attention than the more eddy-rich West Greenland Current, but is a potential source of freshwater in closer proximity to the region of deep convection. Freshwater fluxes from the Arctic and Greenland are expected to increase under a changing climate, and our findings suggest that they may play an active role in the restratification of deep convection.

SUBPOLAR ATLANTIC ARCTIC

The benefits of nuclear waste: Insights into Subpolar North Atlantic ocean circulation using artificial radionuclide tracers.

Duncan Dale[1,*], Lisa Leist[1], Marcus Christl[2], Maxi Castrillejo[3], Andreas Macrander[4], Sólveig Ólafsdóttir[4], Rob Middag[5], John Smith[6] and Núria Casacuberta[1,2]

[1] Institute of Biogeochemistry and Pollutant Dynamics, ETH Zürich, Switzerland
[2] Laboratory of Ion Beam Physics, ETH Zürich, Switzerland
[3] C Cycle Group, Imperial College London, UK
[4] Marine and Freshwater Research Institute, Hafnarfjörður, Iceland
[5] Royal Netherlands Institute for Sea Research (NIOZ), Texel, Netherlands
[6] Bedford Institute of Oceanography, Canada

[*]IASC supported Early Career Scientist

ABSTRACT

Artificial radionuclides have been introduced to the North Atlantic by nuclear weapon tests and continuous discharge from nuclear reprocessing plants (NRPs) in the UK and France since the 1950-60s. Long-lived radionuclides such as iodine-129 and uranium-236 have proven to be effective tracers of Atlantic water circulation pathways and timescales downstream of the NRPs, particularly in the Arctic Ocean. This unique tracer signal is also carried by waters leaving the Arctic southward through Fram Strait into the Nordic seas and ultimately via the Greenland-Scotland passages. We assess the Arctic – Subarctic water circulation using a new dual-tracer approach with iodine-129 and uranium-236 data compiled from the AR7W (2020) and OVIDE (2021) transects in the Subpolar North Atlantic and samples collected around Iceland in 2021, including the GEOTRACES MetalGate process study.

The high iodine-129 and uranium-236 concentrations observed on the western side of Fram Strait provides a markedly specific starting point to gain new insights into the origin and fate of the East Greenland Current and the role of the Recirculating Atlantic Current in the Nordic Seas. Around Iceland, the lower but still distinctive tracer signature presents an independent chemical tracer perspective on the formation and downstream evolution of the major overflow waters, including the contribution of deep-water formation in the Iceland Sea. South of Iceland, although having a more diluted signature of both iodine-129 and uranium-236, we can still follow the evolution of the deep overflow waters within the deep western boundary current and investigate the tracer evolution in Labrador Sea and Subpolar Mode Waters. It is hoped and intended that the unique results of these tracer studies can complement to, and be compared with, conclusions drawn from traditional physical oceanographic techniques.

Marine radiocarbon changes in the North Atlantic since the 1990s.

Maxi Castrillejo[1], Heather D. Graven[1], Byju Pookkandy[1], Joanna G. Lester[1], Lukas Wacker[2], Silvia Bollhalder[2] and Pascale Lherminier[3]

[1] Department of Physics, Imperial College London, London, United Kingdom
[2] Laboratory of Ion Beam Physics, ETH-Zurich, Zurich, Switzerland
[3] Ifremer, Univ. Brest, CNRS, IRD, Laboratoire d'Oceanographie Physique et Spatiale, IUEM, Plouzané, France

ABSTRACT

The radiocarbon isotope ratio ($^{14}C/C$) in dissolved inorganic carbon (DIC) has changed as result of atmospheric nuclear weapon tests (enriched $^{14}C/C$) and the burning of fossil fuels (depleted $^{14}C/C$), making the $\Delta^{14}C$ tracer suitable to study the contemporary circulation. Here we track the $^{14}C/C$ change of DIC in the subpolar and subtropical North Atlantic using observations and model simulations. We report new tracer observations from 2018 along the GO-SHIP A25 transect between Portugal and Greenland, and from 2020 on A05 along 24.5 °N. We compare observations with simulations from the Ocean-Sea-Ice NEMO model and the Community Earth System Model (CESM2.0). We use the model simulations to understand the changing spatiotemporal distributions of $\Delta^{14}C$ measured between the 1990s and present. The tracer observations and simulations broadly agree, but there are important model biases primarily related to the depth and rate of NADW ventilation. For example, the two models fail to capture the overflows in the subpolar region and the southward spreading of the lower NADW into subtropical latitudes. We suspect that being this the case for radiocarbon, the flaws in modelled circulation may also affect the simulated transport of other biogeochemical properties such as anthropogenic carbon.

21st Arctic-Subarctic Ocean Fluxes Workshop
10-12 May, 2023. Gran Canaria, Spain

Assessing the variability of Irminger Water at AR7W between 1993 and 2022 using time-dependent property thresholds.

Kevin N. Wiegand[1,2], Dagmar Kieke[3], Paul G. Myers[4] and Igor Yashayaev[5]

[1] Institute of Environmental Physics (IUP), Dep. Oceanography, University of Bremen, Bremen, Germany
[2] Center for Marine Environmental Sciences – MARUM, University of Bremen, Bremen, Germany
[3] Bundesamt für Seeschifffahrt und Hydrographie (BSH), Hamburg, Germany
[4] Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, Canada
[5] Bedford Institute of Oceanography, Dartmouth, Canada

ABSTRACT

Irminger Water (IW) is a prominent water mass in the subpolar North Atlantic (SPNA). It is warm and saline and originates from the North Atlantic Current and the Irminger Current. The water mass delivers large amounts of heat and salt to the Labrador Sea. Like any other water mass, IW is subject to temporal and spatial variability, which needs to be adequately identified and tracked to better understand its effects on, for example, the stratification in the Labrador Sea.

Previous studies identified IW at different times using static thresholds of salinity, temperature, and density (i.e., constant over time within the individual studies) to separate IW from ambient waters. However, given the tremendous variability in the region, such static definitions often do not detect IW sufficiently since these definitions do not account for shifts in the large-scale hydrographic state of the SPNA. To address this issue, this study aims to identify non-static thresholds (i.e., incorporating temporal variability) to analyze IW variability. Here, the IW variability is individually identified in the Irminger Sea and is transferred to different locations within the boundary current. We refer to the approach of identifying IW based on non-static thresholds as the provenance method, as it refers to the Irminger Sea as the provenance of IW variability. To do so, we utilize the observation-based data set ARMOR3D between 1993 and 2022. This new approach allows us to compare estimates of IW properties and volume transports to respective estimates obtained from the static method.

In the case of the static method being applied to the AR7W section in the eastern part of the Labrador Sea as a test region, the water column was anomalously saline in years of high IW volume transport. Hence, the static method identified more IW and thus overestimated its volume transport. In contrast, the water column was anomalously fresh in years when the static method revealed a low IW volume transport. Hence, applying the static approach, less IW is identified, and thus its volume transport is underestimated. In contrast, the provenance method reveals less pronounced decadal variability of the IW volume transport.

Applying a static IW definition will likely create stronger gradients between IW and ambient water masses when both are fresher. In turn, these gradients may impose or modulate unrealistic changes in the IW volume transport simply because the actual boundary of IW does not coincide with a certain isohaline or isotherm. Any correlated change or shift in IW properties and, for example, Labrador Sea Water will relocate the IW boundary causing the transport to change. The provenance method introduced in our study resolves this issue.

Time series measurements of transient tracers and tracer derived transport in the Deep Western Boundary Current off Bermuda.

John N. Smith[1,*], Nuria Casacuberta[2,3], Anne-Marie Wefing[3], Marcus Christi[2] and Rod Johnson[4]

[1] Bedford Institute of Oceanography, Dartmouth, NS, Canada
[2] Laboratory of Ion Beam Physics, ETH Zurich, Zurich, Switzerland
[3] Institute of Biogeochemistry and Pollutant Dynamics, ETH Zürich, Switzerland
[4] Bermuda Institute of Ocean Sciences, St. George's, Bermuda

[*]On-line speaker

ABSTRACT

Time series measurements of the nuclear fuel reprocessing tracers, 129I and 236U and the gas ventilation tracer, CFC-11 have been undertaken in the Labrador Sea and on Line W, located over the US continental slope off Cape Cod and over the continental rise south of Bermuda, to determine advection and mixing time scales for the transport of Denmark Strait Overflow Water (DSOW) within the Deep Western Boundary Current (DWBC) and through interior pathways. The Labrador Sea tracer and hydrographic time series data were used as input functions in a boundary current model that employs transit time distributions to simulate the effects of mixing and advection on downstream tracer distributions. Model simulations of tracer levels in the boundary current core and adjacent interior (shoulder) region with which mixing occurs were compared with the Line W time series measurements to determine boundary current model parameters. These results indicate that DSOW is transported from the Labrador Sea to Line W via the DWBC on a time scale of 5-6 y corresponding to a mean flow velocity of 2.7 cm/s while mixing between the core and interior regions occurs with a time constant of 2.6 y. A tracer section over the southern flank of the Bermuda rise indicates that the flow of DSOW that separated from the DWBC had undergone transport through interior pathways on a time scale of 9 y with a mixing time constant of 4.

Relating subpolar watermass transformation to subtropical overturning.

Eleanor Frajka-Williams[1,*]

[1]Universität Hamburg, Germany

[*]On-line speaker

ABSTRACT

Recent results from AMOC (Atlantic Meridional Overturning Circulation) observing arrays show no apparent relationship between transport variability observed at different latitudes. The subpolar overturning computed from observations between Canada, Greenland and Scotland varies primarily with watermass transformation east of Greenland and does not depend on western boundary densities; the subtropical overturning between the Bahamas and Canary Islands varies primarily with western boundary dynamic height anomalies on interannual and longer timescales. Tracer-based investigations (including from CFCs or spice—T/S anomalies on isopycnals) show that deep property anomalies originate in the subpolar North Atlantic and appear at some later time in the western boundary of the subtropical Atlantic, showing a clear connection between watermasses formed at northern high latitudes and those found at depth in the subtropics. Here, we ask what is the relationship between property anomalies and transport anomalies, using spice and dynamic height at the western boundary of the subtropics. The spice allows us to relate the observed property changes to watermasses formed in the subpolar North Atlantic, while dynamic height tells us what relationship these property anomalies have with the transport variability observed further south. This approach offers the potential to better understand how processes in the subpolar North Atlantic influence the large-scale ocean circulation.

Mixing and air-sea buoyancy fluxes set the time-mean overturning circulation in the subpolar North Atlantic and Nordic Seas.

D. Gwyn Evans[1], N. Penny Holliday[1], Sheldon Bacon[1] and Isabela Le Bras[2]

[1] National Oceanography Centre
[2] Woods Hole Oceanographic Institution

ABSTRACT

Recent results from AMOC (Atlantic Meridional Overturning Circulation) observing arrays show no apparent relationship between transport variability observed at different latitudes. The subpolar overturning computed from observations between Canada, Greenland and Scotland varies primarily with watermass transformation east of Greenland and does not depend on western boundary densities; the subtropical overturning between the Bahamas and Canary Islands varies primarily with western boundary dynamic height anomalies on interannual and longer timescales. Tracer-based investigations (including from CFCs or spice—T/S anomalies on isopycnals) show that deep property anomalies originate in the subpolar North Atlantic and appear at some later time in the western boundary of the subtropical Atlantic, showing a clear connection between watermasses formed at northern high latitudes and those found at depth in the subtropics. Here, we ask what is the relationship between property anomalies and transport anomalies, using spice and dynamic height at the western boundary of the subtropics. The spice allows us to relate the observed property changes to watermasses formed in the subpolar North Atlantic, while dynamic height tells us what relationship these property anomalies have with the transport variability observed further south. This approach offers the potential to better understand how processes in the subpolar North Atlantic influence the large-scale ocean circulation.

A quasi-synoptic estimation of Anthropogenic Carbon Inventories in the Arctic Ocean and Subpolar North Atlantic in 2015.

Raimond L.i.[1,2], Wefing A-M.[1,*], Wallace D.W.R[2], Azetzu-Scott K.[3] and Casacuberta N.[1]

[1] Institute of Biogeochemistry and Pollutant Dynamics, Department of Environmental Systems Science, and Laboratory of Ion Beam Physics, ETH Zürich, Zürich, Switzerland
[2] Department of Oceanography, Dalhousie University, Halifax, Nova Scotia, Canada
[3] Bedford Institute of Oceanography, Fisheries and Oceans Canada, Dartmouth, Nova Scotia, Canada

[*]Fundación DISA supported Early Career Scientist

ABSTRACT

Recent results from AMOC (Atlantic Meridional Overturning Circulation) observing arrays show no apparent relationship between transport variability observed at different latitudes. The subpolar overturning computed from observations between Canada, Greenland and Scotland varies primarily with watermass transformation east of Greenland and does not depend on western boundary densities; the subtropical overturning between the Bahamas and Canary Islands varies primarily with western boundary dynamic height anomalies on interannual and longer timescales. Tracer-based investigations (including from CFCs or spice—T/S anomalies on isopycnals) show that deep property anomalies originate in the subpolar North Atlantic and appear at some later time in the western boundary of the subtropical Atlantic, showing a clear connection between watermasses formed at northern high latitudes and those found at depth in the subtropics. Here, we ask what is the relationship between property anomalies and transport anomalies, using spice and dynamic height at the western boundary of the subtropics. The spice allows us to relate the observed property changes to watermasses formed in the subpolar North Atlantic, while dynamic height tells us what relationship these property anomalies have with the transport variability observed further south. This approach offers the potential to better understand how processes in the subpolar North Atlantic influence the large-scale ocean circulation.

Project talks and synergies

Synoptic Arctic Survey maps climate change in the Arctic Ocean.
Maria Teresa Bezem*. Geophysical Institute, University of Bergen, Norway,

Developing a pan-Arctic network of Distributed Biological Observatories (DBOs).
Anna Nikolopoulos*. Norwegian Polar Institute, Norway.

Iceland Faroe GLider Ocean Observations (IFGLOO) project.
Angel Ruiz-Angulo. ETH Zurich, Switzerland.

A new field program investigating dense water pathways to the Faroe Bank overflow.
Robert S Pickart. Woods Hole Oceanographic Institution, U.S.A.

A new field program investigating water mass transformation in the East Greenland Current.
Kjetil Våge. Geophysical Institute, University of Bergen and Bjerknes Centre for Climate Research, Norway

Investigating the far-reaching impacts of dense water overflows in the North Atlantic Ocean: the 2023 FARDWO cruise in the Denmark Strait.
Anna Sanchez-Vidal*. GRC Geociències Marines, Universitat de Barcelona, Spain

Transport and fate of the Labrador Coastal Current: plan for 2023 fieldwork.
Nicholas Foukal, Woods Hole Oceanographic Institution, Ma., USA.

Physical oceanography around Iceland: Present and future research of Hafrannsóknastofnun.
Andreas Macrander*. Hafrannsóknastofnun (Marine and Freshwater Research Institute), Iceland

*Online Speakers.

ASOF
21st Arctic-Subarctic Ocean Fluxes Workshop
10-12 May, 2023. Gran Canaria, Spain

IASC · ULPGC Universidad de Las Palmas de Gran Canaria · IOCAG Instituto de Oceanografía y Cambio Global · Fundación DISA · GranCanaria Convention Bureau

Outreach event / Sesión divulgativa

4 de mayo, 2023 de 10:00 a 12:00
Salón Dámaso del Real Club Náutico de Gran Canaria

Calentamiento Global en el océano y sus impactos en el Archipiélago Canario. Acciones de mitigación y adaptación en Gran Canaria.

10:00. Presentación de la sesión.
Mª Dolores Pérez Hernández. Profesora de la ULPGC, Grupo GOF del IOCAG.

10:05. Impactos químicos en el océano. Acidificación y sus efectos.
Magdalena Santana Casiano. Catedrática de la ULPGC, Grupo QUIMA del IOCAG.

10:25. Consecuencias físicas del calentamiento global.
Alonso Hernández Guerra. Catedrático de la ULPGC, Grupo GOF del IOCAG.

10:45. Microplásticos en aguas abiertas en la región de Canarias marino.
Daura Vega Moreno. Profesora de la ULPGC, Departamento de Química.

11:05. Economía Circular como modelo de lucha contra el cambio climático.
Aridane González González. Profesor de la ULPGC, Grupo QUIMA del IOCAG. Presidente del Comité de Personas Expertas para el Estudio del Cambio Climático en Canarias y el Fomento de la Economía Circular y Azul.

11:25. Medidas e iniciativas de mitigación y adaptación en Gran Canaria.
Raúl García Brink. Coordinador Técnico de Desarrollo Económico, Soberanía Energética, Clima y Conocimiento en Cabildo de Gran Canaria.

11:40. Mesa Redonda de discusión.

Exposición en la sala: "Una mirada polar"

Pocas áreas geográficas de nuestro planeta son tan fascinantes y, a su vez, tan desconocidas como las regiones polares. Su gran interés científico reside en el importante y decisivo papel que juegan en la dinámica y el futuro de nuestro planeta, especialmente en el actual contexto de cambio global, ya que las regiones polares son los grandes y principales motores reguladores del clima de la Tierra. Los drásticos cambios que están sufriendo en respuesta al aumento de temperatura, ocasionado por el incremento en la emisión de gases de efecto invernadero como consecuencia de las actividades humanas, están afectando directamente a la dinámica climática, oceanográfica y ambiental, tanto de los propios polos como de latitudes extrapolares. Esta exposición de fotografías persigue mostrar la belleza de estas regiones tan remotas a la par que proporcionar una visión integral y multidisciplinar del estado del conocimiento de las zonas polares, remarcando las semejanzas y diferencias entre el Ártico y la Antártida. Especialmente, busca concienciar a las nuevas generaciones sobre la importancia y vulnerabilidad de las regiones polares. Además, pretende resaltar la necesidad de una investigación enfocada a comprender y evaluar su papel en el futuro incierto de nuestro planeta en un contexto de transformación derivada del cambio global actual.

@IOCAG1 https://iocag.ulpgc.es/
#ASOF https://asof.awi.de/
@RCNGC https://www.rcngc.com/

@IASC_Arctic https://iasc.info/
@FundacionDISA https://www.fundaciondisa.org/