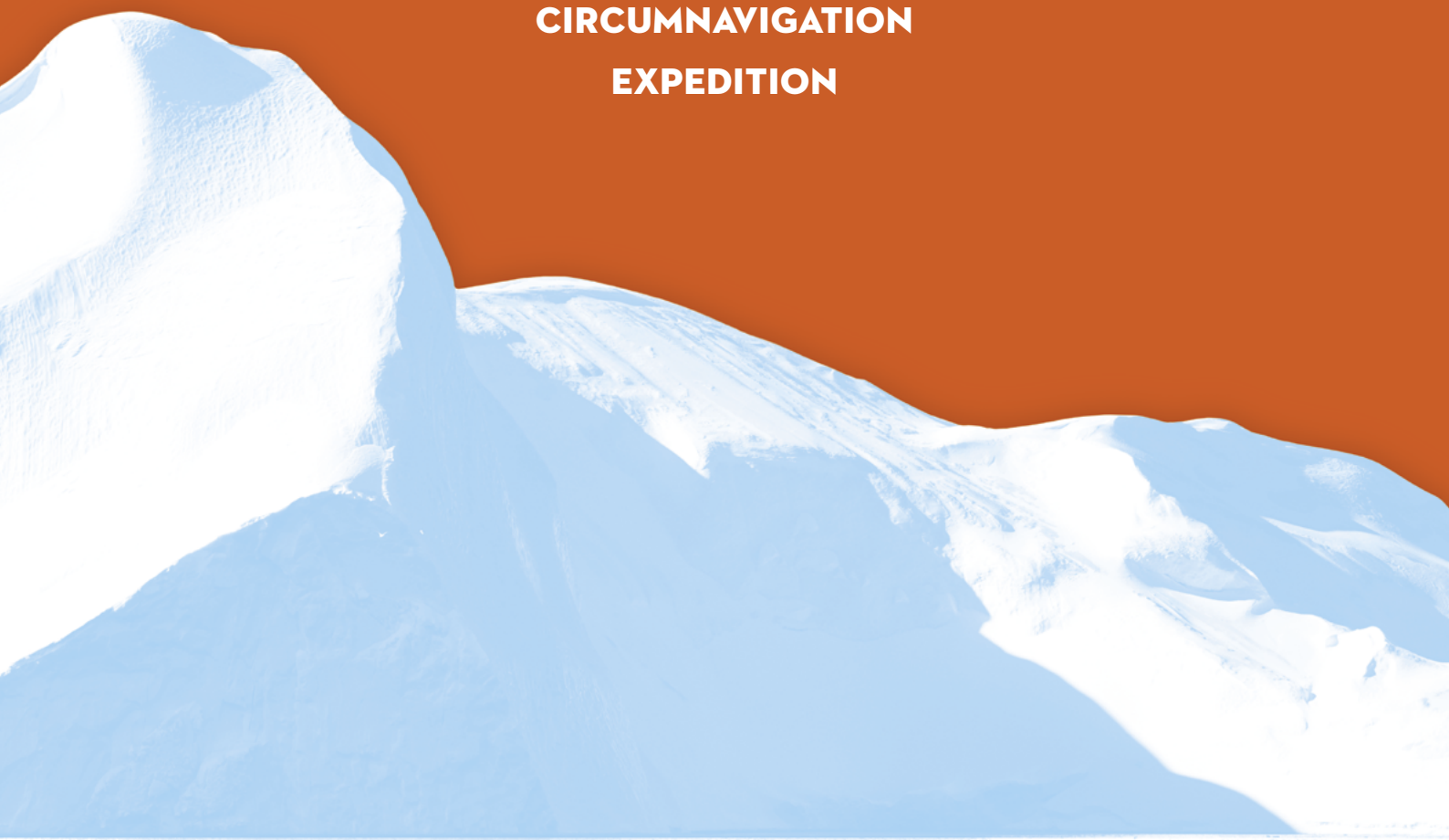
GLACE

GREENLAND
CIRCUMNAVIGATION
EXPEDITION



SWISS POLAR
INSTITUTE

GLACE

GREENLAND CIRCUMNAVIGATION EXPEDITION

UNDERSTANDING THE ARCTIC: THE GREENLAND CIRCUMNAVIGATION EXPEDITION GLACE

GLACE will take scientific teams from all over the world on a complete circumnavigation of Greenland over a two-month period in August and September 2019 on board the research vessel Akademik Tryoshnikov. Along the North of Greenland, the ship will be working in convoy with an atomic ice breaker to break the multi-annual ice and provide access to the largely unchartered Northern Greenland.

GLACE starts in Reykjavik on 4 August 2019, proceeding clockwise around Greenland with a stopover in Ilulissat on Greenland's West coast. Three super sites in Southern Greenland and four in Northern Greenland have been identified for prolonged stops to allow for multi-disciplinary and land-based investigations.

GLACE is the second large expedition of SPI, emphasising the importance of Swiss polar research on a global level, as well as highlighting the Swiss Polar Institute as a facilitator of major international research activities in polar regions. GLACE is a scientific expedition, organised by the Swiss Polar Institute SPI and supported by the Swiss Polar Foundation. The Swiss Polar Institute SPI was created to provide dedicated support to, offer new opportunities and promote synergies within the polar community in Switzerland.

During the expedition, interested scientists and the wider public will be able to follow the work and life on board through the expedition's blog and social media.

Follow **GLACE** through **www.GLACEexpedition.ch**

POLAR AMPLIFICATION, SEA-ICE MELT AND OCEAN CIRCULATION CHANGES – A FEW OF THE MANY REASONS TO UNDERSTAND THE ARCTIC BETTER

The Arctic region and Greenland in particular have both been considerably affected by global warming. As a result of polar amplification, temperatures have increased by 2-3°C within the last decades – well above the globally averaged temperature increase of 1°C.

One of the most dramatic manifestations of warming in the Arctic relates to the substantial decrease in sea-ice cover affecting oceanic heat uptake and marine biological production.

Furthermore, increasing temperatures contribute to accelerate glacier melt both in the Arctic realm and in Greenland with meltwater contributing to sea-level rise and measurable large-scale ocean circulation changes. Increased nutrient and sediment supply associated with glacial runoff modify coastal and open ocean ecosystems, with shifting phytoplankton communities affecting the entire food chain, including birds and mammals.

The warming environment also presents major challenges to local communities, notably affecting natural resources and infrastructures.

From this perspective, furthering our understanding underlying the complex interactions between the terrestrial biosphere, the cryosphere, the ocean and atmosphere will offer opportunities to better preserve these unique ecosystems in the future.

INDICATIVE TRAVEL PLAN

3 SUPER SITES NORTHERN GREENLAND – LEG 2

NG1
RYDER & OSTENFELD GLACIER
82°20'N, 52°16'W
82°12'N, 47°48'W

NG2
CAPE MORRIS JESSUP
83°38' N, 32°39' W

NG3
INDEPENDENCE FJORD
82°08' N, 28°00' W

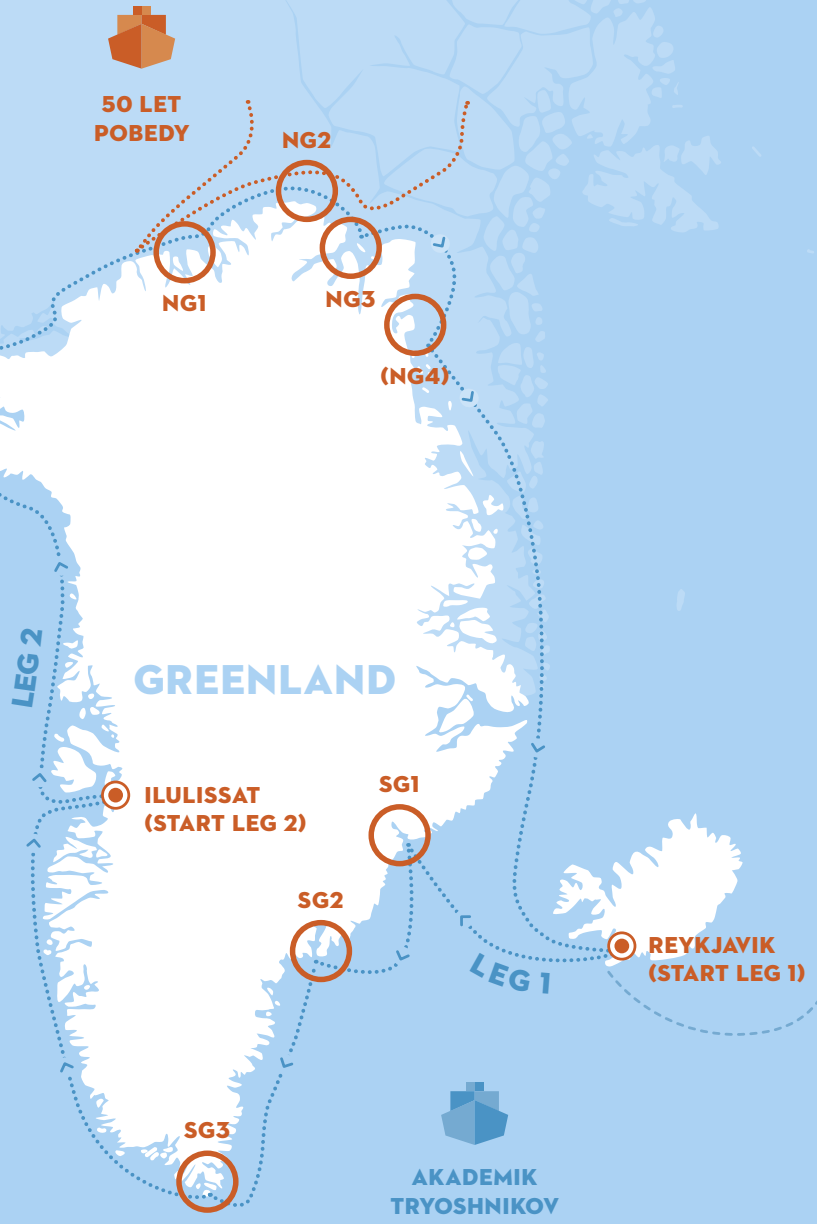
(NG4, BACKUP)
ZACHARIAE GLACIER
79°31'N, 19°25'W

3 SUPER SITES SOUTHERN GREENLAND – LEG 1

SG1
KANGERDLUGSSUAQ FJORD
68°14'N, 32°05'W

SG2
SERMILIK (HELHEIM) FJORD
66°05'N, 37°48'W

SG3
PRINCE CHRISTIAN SUND
60°09'N, 43°53'W



VESSEL TIME LINE 2019

30 JULY
Departure in Kiel
(to Reykjavik)

4 AUGUST
Circumnavigation starts in Reykjavik

LEG 1

CA. 19 AUG.
Arrival in Ilulissat

CA. 20 AUG.
Departure in Ilulissat

LEG 2

CA. 24 SEPT.
Circumnavigation ends in Reykjavik

29 SEPT.
Arrival in Kiel

15 PROJECTS, ONE EXPEDITION

GLACE is composed of 15 different, synergistic research projects, bringing together scientists from a wide range of disciplines and from around the globe. Research questions will target the physics, chemistry and biology of sea-ice, glaciers, lake sediments, terrestrial ecosystems, the ocean, and the sea floor.

Swiss polar science has a strong standing on the expedition, as six of the research projects are led by scientists from Swiss research institutions.

For this first full circumnavigation of Greenland, the 44 selected scientists will have helicopters and zodiacs at their disposal as well as different laboratories both on the ship and in dedicated laboratory containers. This will allow them to work around the clock and conduct real time experiments in addition to collecting and storing unique samples and data. The scientists on board the expedition will benefit from a large support team composed of mountain guides, zodiac and helicopter pilots, lab assistants and technicians as well as a management team with wide range of competences.

The expedition will provide access to the remote, yet critically understudied Northern Greenland area and foster interdisciplinary research towards a holistic view of this rapidly changing region, which influences the climate globally.

The following pages will provide an introduction of each of the projects, their participants, objectives, and approaches.

University of Texas at San Antonio

SEA ICE THICKNESS UNDER ARCTIC CLIMATE CHANGE

Category
Cryosphere

Principal Investigator (PI)
Stephen Ackley
University of Texas at San Antonio (UTSA)

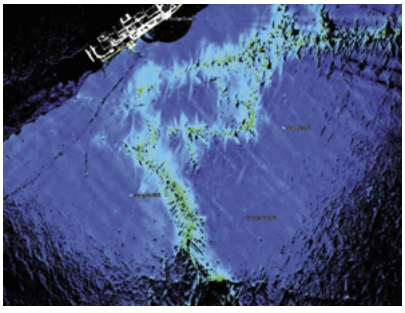
Country
USA

Scientific Project Name
Arctic Sea Ice on GLACE

Understanding the Arctic sea ice cover is key as an indicator of the rapidity of global warming, for its role in accelerating atmospheric change through processes such as ice-albedo feedback, and its impact on the global thermohaline circulation by changes in the mass of sea ice advected out of the Arctic Basin through Fram Strait. Ice elevation measurements by LiDAR on board the IceSAT 2 satellite can provide better regional scales to characterise the ice cover but lack validation data at the appropriate regional scales.

The rapidly changing characteristics of the Arctic and the few studies north of Greenland and in the East Greenland outflow make the GLACE expedition a unique opportunity to greatly expand the sea ice data set, both at high resolution and over spatial scales compatible with remote sensing. UTSA's unique Sea Ice Measurement System on the GLACE vessel can make sea ice measurements for the parameters of ice thickness, snow depth, ice concentration, ice roughness, ice elevation (freeboard), melt pond coverage, and ice surface temperature over the vessel track line while the vessel is underway during leg 2 to North and East Greenland.

Our goal is to characterise these sea ice covers as they have evolved from the previous period to the present "New Normal" for the Arctic, and to use the ship-based validation to convert IceSAT-2 elevation data to ice thickness for this rapidly changing region now and in the future.



University of Ottawa

GREENLAND LAKE CORING EXPEDITION

Category
Terrestrial

Principal Investigator (PI)
Jules Blais
University of Ottawa

Country
Canada

Scientific Project Name
Paleoclimate and anthropological reconstructions from Greenland lacustrine sediments using untargeted and targeted analyses

Contributing Institutions
Queen's University, Kingston, ON (Canada)
McGill University, Montreal, QC (Canada)

We use lake sediments to investigate questions requiring a long-term perspective on the effects of climate change and other environmental perturbations on ecosystems. Here we propose to apply our lake sediment coring methods to study:

- ecological and climatological changes in Greenland
- historical Arctic cultures such as the Paleoeskimo, Thule and the Norse who occupied Greenland over a thousand years ago.

We propose to develop a novel untargeted "omics"-based method to discover next-generation sediment biomarkers and to corroborate this information with more traditional targeted biomarkers, microfossils, and microbial DNA. We are planning to extend this technique to examine organic compounds deposited during the time of the Paleoeskimo, Thule and Norse to determine novel biomarkers for their presence, and to discover additional paleo-ecological biomarkers relevant to the Arctic. We also plan to use metagenomes extracted from dated sediment cores to develop novel taxonomic or functional biomarkers of human presence by targeting the human gut microbiota. Targeted analysis will include investigations into sterols/stanols, diatoms, stable isotopes (like δ15N), metals (like Hg), polycyclic aromatic hydrocarbons (as tracers of fuel burning), alkanes (tracers of plant waxes) and pigments.

Our goal is to develop new tools to track historical climatic changes and possibly human presence in Arctic environments using dated lake sediments.

Arctic and Antarctic Research Institute

PALEOENVIRONMENTAL ARCTIC CHANGE (PEACE)

Category
Terrestrial

Principal Investigator (PI)
Dmitry Bolshiyanov
Arctic and Antarctic Research Institute

Country
Russian Federation

Scientific Project Name
Reading Arctic climatic and sea level fluctuations in the Past on a base of lake sediments and ancient shorelines investigations

Contributing Institutions
Swiss Polar Institute (Switzerland)
St. Petersburg State University (Russia)
Institute of Geology (Estonia)
University of Technology (Estonia)

The primary focus of the PEACE project during GLACE is to collect data for paleo-environmental reconstructions. The main objects of investigation are ancient coastlines and lake sediments, which are archives of paleoclimate information and witnesses of sea level fluctuations during the Holocene.

The planned fieldwork includes:

- Measuring the altitude of terraces and coastlines of Greenland at the super sites.
- Sampling organic material and loose sediments of terraces and coastlines to carry out carbon-14, IRSL- and ESR- dating.
- Geomorphologic mapping of coastline areas.
- Core sampling from the lakes located on different altitudes above the current sea level.

We mainly aim to reconstruct climate fluctuations and sea level changes during the last centuries and millennia. The results will provide additional data to be included and compared with the data from longstanding paleo-geographical investigations in the Russian Arctic and in Antarctica.

Greenland Institute of Natural Resources

AALISAKKAT: FISH AND ZOOPLANKTON AROUND GREENLAND

Around Greenland, fish and zooplankton are a major food source for marine mammals, seabirds and commercial fish species. Greenland's economy is highly dependent on fisheries (90% of export value), and climate change has profound effects on marine ecosystems and the future of fisheries in the country. The project aims to map the current distribution of zooplankton and pelagic fish populations around Greenland as a baseline for future studies on climate change.

Our approach includes fisheries acoustics, net sampling and environmental DNA. The knowledge gained during this project will help the assessment of natural resources and provide scientific advice on managing fish stocks in Greenland.

Category
Ocean

Principal Investigator (PI)
Caroline Bouchard
Greenland Institute of Natural Resources

Country
Greenland

Scientific Project Name
Aalisakkat: distribution of fish and zooplankton around Greenland

Contributing Institutions
Greenland Institute of Natural Resources GINR (Greenland)
Memorial University of Newfoundland MUN (Canada)

Swiss Federal Research Institute WSL

GAINING A HOLISTIC VIEW OF TERRESTRIAL BIODIVERSITY IN GREENLAND

Category
Terrestrial

Principal Investigator (PI)
Beat Frey
Swiss Federal Research Institute WSL

Country
Switzerland

Scientific Project Name
Biogeography, biodiversity and shrub growth under Greenland's current and future climate conditions (BioShrubGreenLand)

Contributing Institutions
Swiss Federal Research Institute WSL/SLF (Switzerland)
University of Copenhagen (Denmark)
University of Aarhus (Denmark)
British Antarctic Survey (UK)
Northumbria University (UK)

The project BioShrubGreenLand aims at deciphering the evolutionary history of terrestrial microorganisms and plants in Greenland, and investigates which factors drive species distribution and terrestrial biodiversity patterns.

The unique samples collected for the project will provide completely novel information on the biodiversity and distribution of the majority of terrestrial organisms in many new Greenlandic locations.

We hope to predict how Greenlandic terrestrial biodiversity will change under future climate change by linking baseline biodiversity data of terrestrial soil taxa and plants in Greenland to existing climate data.

Greenland is a perfect natural "laboratory" to study distribution patterns of soil taxa and plants representing the entire circumpolar region, as it covers most climate and vegetation zones in the Arctic. GLACE also uniquely enables sampling from rarely visited sites in northern Greenland.

University of Manitoba

IMPACT OF GLACIAL MELTWATER DISCHARGE ON FRESHWATER-MARINE COUPLING ACROSS THE GREENLAND SHELVES

Arctic climate change manifests itself in freshening of the surface seawater over recent decades due to increased precipitation, river runoff, and glacier- and sea-ice melt. Sea ice and glaciers are melting at unprecedented rates. The Greenland Ice Sheet (GIS) melt has accelerated since the 1990s with potentially major consequences on the hydrography, biogeochemical cycles, and marine productivity in the Greenlandic coastal ecosystem.

The objectives of the interdisciplinary project BIGDEAL are to determine the glacial meltwater discharge entering the Arctic from the GIS and its impacts on biogeochemical cycles of carbondioxide, methane and mercury, and sea ice dynamic and thermodynamic processes. Those goals will be achieved through collaboration between teams specialized in physical oceanography, glaciology, and biogeochemistry.

Glacial meltwater is assumed to have unique biogeochemical characteristics. Changes in the glacial meltwater discharge may strongly influence coastal productivity around Greenland with large ecological and socio-economic impacts. Our research output will assist marine resource managers in identifying sustainable practices and establishing community-based monitoring targets for regional fisheries in response to increasing freshwater fluxes. These targets will assist communities and local governments in developing strategies to mitigate changing sea and glacier ice conditions and contaminant exposure via the consumption of marine food.

Category
Ocean & Cryosphere

Principal Investigator (PI)
Nicolas-Xavier Geilfus
University of Manitoba

Country
Canada

Scientific Project Name
Biogeochemical Impacts of Glacial Drainage: Examining Arctic Linkages (BIGDEAL)

Contributing Institutions
Aarhus University (Denmark)
University of Calgary (Canada)
University of Manitoba (Canada)
Université de Liège (Belgium)

Alfred Wegener Institute for Polar and Marine Research

OBSERVING THE STATE AND CHANGE OF GREENLAND'S SEA ICE COVER

Category
Cryosphere

Principal Investigator (PI)
Christian Haas
Alfred Wegener Institute for Polar and Marine Research (AWI)

Country
Germany

Scientific Project Name
GreenLAnd Sea Ice Survey (GLASIS)

The sea ice cover in the Arctic has strongly retreated. However, the waters around Greenland are still home to the oldest and thickest multiyear ice in the Arctic. Through Fram and Nares Straits in the East and West of Greenland large amounts of sea ice and freshwater are released to the North Atlantic where they strongly affect climate and ecosystem processes, and where sea ice poses a hazard to marine operations. Little is known about how the region's sea ice has changed.

We will carry out extensive ice thickness surveys in Nares Strait, north of Greenland, and in Fram Strait to assess the state of the sea ice in those important regions, and to observe the regionally varying thinning rates. Surveys will be carried out with the ship's helicopter using an electromagnetic (EM) thickness sounder and on ice floes whenever they can be accessed. Airborne video observations of melt pond coverage will complement the measurements. Together with ice thickness surveys carried out by our group in the same region during spring, the GLASIS summer surveys will also provide important information about seasonal thinning rates between spring and summer. With thickness being one of the key sea ice properties, the planned observations are important for the detection, quantification, and improved prediction of Arctic sea ice change, and complement remote sensing, oceanographic observations, and modelling studies.

University of Lausanne

GREENLAND ICE AND SEDIMENT TRANSECT

Category
Ocean & Cryosphere

Principal Investigator (PI)
Frédéric Herman
University of Lausanne

Country
Switzerland

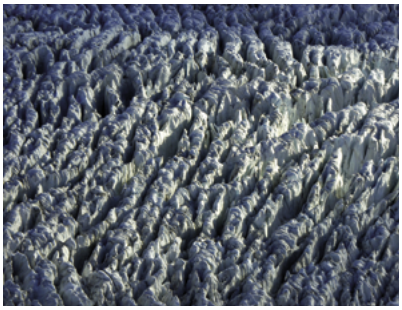
Scientific Project Name
GRIST

Contributing Institutions
University of California, Irvine (USA)
Jet Propulsion Laboratory-Caltech
University of Washington (USA)
University of British Columbia (Canada)

Greenland glaciers melt and slide faster when in contact with warm, salty, subsurface ocean water. Additionally, where glaciers slide, they erode their bed, producing large volumes of sediments and transporting them to the ice margin where they accumulate. The large volumes of sediment accumulation can affect the retreat dynamics by forming shoals that buttress the termini and decrease the surface area available for submarine melting. However, how exactly this works is not yet fully understood due to a lack of observation.

To improve this understanding, we will determine the rate of sediment production by glacial erosion from field measurements of bathymetry, water characteristics, and sediment yields at each of the super-sites, over a wide range of climatic settings, with mean annual air temperature ranging from near 0°C in the South to -10 °C in the North.

Quantifying the fluxes of freshwater and sediment is of broader interest because these fluxes deliver substantial amounts of bio-essential nutrients to downstream ecosystems locally and regionally, and they figure in global geochemical cycles. For instance, a recent study suggests that 8 % of modern export of suspended sediments from the continents to the oceans globally may come from the Greenland ice-sheet alone. This volume is considerable and has diverse, significant implications. There is therefore a need to quantify the current fluxes and to project how they are likely evolving in the future.



ETH Zurich

IDENTIFYING MICROSCOPIC OCEAN PARTICLES THAT HELP FORM ICE CRYSTALS IN ARCTIC CLOUDS

Category
Atmosphere

Principal Investigator (PI)
Zamin Kanji
ETH Zurich

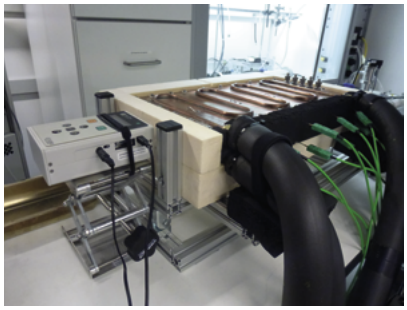
Country
Switzerland

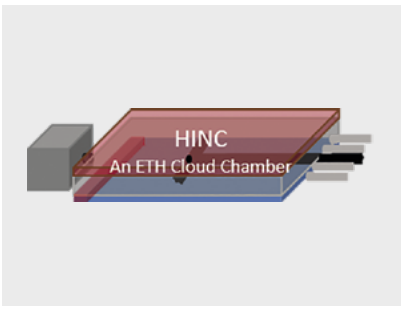
Scientific Project Name
INIGMA – Ice Nucleating particles in the Greenland Marine Atmosphere

Contributing Institutions
ETH Zurich (Switzerland)
Finnish Meteorological Institute (Finland)

Clouds covering the Arctic Ocean are unique in that they can persist for long periods despite being thermodynamically unstable, because they are composed of ice crystals and liquid droplets (mixed phase clouds). Understanding the phenomenon of those persisting clouds is important as mixed phase clouds strongly affect the regional surface energy budget and influence the ice mass budget, as well as the surface water melt and run-off.

Ice crystals in the arctic clouds can only form on existing microscopic particles called ice nucleating particles (INPs). These INPs are thought to be emitted by the oceans in northern latitudes. In our project, we will sample, identify and quantify these microscopic particles coming from the ocean water and the ocean surface, and determine how they partition into the marine atmosphere in the arctic region. We will do this by sampling the air above the ocean water while circumnavigating Greenland.





University of Basel

IMPACT OF GREENLAND ICE MELT ON OCEAN PRODUCTIVITY

Category
Cryopshere

Principal Investigator (PI)
Moritz Lehmann
Department of Environmental Sciences, University of Basel

Country
Switzerland

Scientific Project Name
GreenMelt - Impact of Greenland ice melt and discharge on marine biogeochemistry, nutrient fluxes, and productivity

Contributing Institutions
Institute of Geological Sciences & Oeschger Centre for Climate Change Research, University of Bern (Switzerland)
Division of Earth & Ocean Sciences, Duke University (USA)
GEOMAR (Germany)
Institut de Ciències del Mar, CSIC (Spain)

The Arctic Ocean around Greenland is one of the prime sentinels of the Earth's climate. It exerts important controls on the global ocean circulation, and in turn on the distribution and transport of nutrients and heat. Primary productivity, the photosynthetic fixation of CO_2 into organic matter, is an important component of the global carbon cycle. It consequently affects marine ecosystem dynamics and global climate. The Greenland ice sheet has been melting at unprecedented rates as a consequence of global warming. The physical and chemical effects of freshwater addition to the Arctic Ocean are multifaceted, and can either operate in tandem or oppose each other.

The main objective of the project GreenMelt is to investigate the links between ice-loss-associated nutrient fluxes to coastal- and open-ocean ecosystems, and related consequences for primary production and processes that affect the air-sea fluxes of climate-relevant gases in the Arctic Ocean around Greenland. Iron (Fe) and nitrogen (N), key elements that are crucial for phytoplankton growth, are the prime focus of investigation. We expect that the contribution of meltwater to the iron and nitrogen inventories in the coastal- and open-ocean waters around Greenland have a strong impact on nutrient availability, ecosystem productivity and diversity, as well as the CO_2 and N_2O gas exchange between the surface ocean and the atmosphere.

École Polytechnique Fédérale de Lausanne

UNDERSTANDING THE MULTIPLE FACETS OF ARCTIC AIRBORNE PARTICLES AND THEIR IMPACTS

Category
Atmosphere

Principal Investigator (PI)
Athanasios Nenes
École Polytechnique Fédérale de Lausanne

Country
Switzerland

Scientific Project Name
Sources and Properties of Arctic Aerosol that affect its Regional Climate (SPAARC)

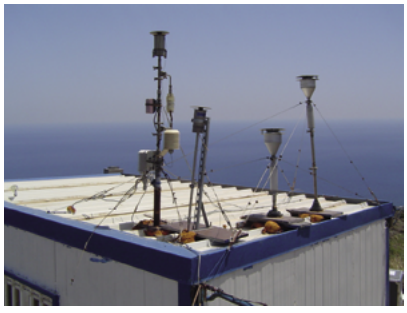
Contributing Institutions
Paul Scherrer Institute (Switzerland)
Institut de Ciències del Mar, Barcelona (Spain)
Northumbria University (United Kingdom)

This project aims to investigate how airborne particles (aerosols) influence the rapidly changing Arctic, by constraining properties that involve their direct influence on the Arctic energy budget, their effect on the formation of clouds, and the alteration of the Arctic nutrient budgets that affect biogenic aerosol sources.

Specifically, we will carry out measurements to determine:

- the ability of Arctic aerosol to absorb solar radiation and heat the atmosphere and surface;
- the source processes of local emissions that contribute to atmospheric aerosol levels, and
- the diversity and sources of airborne microorganisms to estimate their potential role in modulating clouds.

Analysis of the data collected will then help develop relationships of climate-relevant properties of Arctic aerosol for use in attribution and impact assessment studies.



Greenland Institute of Natural Resources

SEABED PROPERTIES AROUND GREENLAND AND FLORA AND FAUNA SAMPLING IN REMOTE AREAS

Category
Ocean & Terrestrial

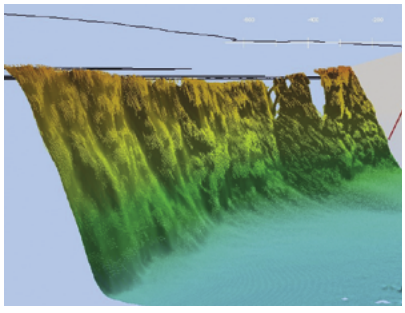
Principal Investigator (PI)
Josephine Nymand Greenland Institute of Natural Resources

Country
Greenland

Scientific Project Name
GL-GLACE

The Greenland Institute of Natural Resources in Nuuk, Greenland, will conduct measurements of the seabed terrain and its properties during GLACE. The data will be used by scientists to understand the marine geology and the influence of submerged currents in the ocean on the melting of the Greenland Ice Cap. The depth data will be included in the large databases on Arctic bathymetry, which is widely used in science - as well as in public services such as Google Earth for the Oceans.

The project also includes a terrestrial part where we plan on collecting samples and doing analyses on land, in freshwater and in coastal areas. The sampling will be done on e.g. vegetation, arthropods, seaweed, fish, and freshwater to update our basic knowledge on the biology and the environment in general. Furthermore, we will collect samples from specific species to gain novel data on background levels of radionuclides. We will use the data from the super-sites NG1, NG2 and NG3 for comparisons between the sites, and to compare them with data gained from the long-term monitoring sites in the Greenland Ecosystem Monitoring network. While the ship is underway, we will carry out marine mammal and sea bird observations (MMSO). All data collected will be highly valuable and will provide knowledge from remote areas, which normally are inaccessible.



University of Cape Town

MEASURING LEVELS AND IMPACTS OF PLASTIC POLLUTION AROUND GREENLAND

Category
Ocean & Terrestrial

Principal Investigator (PI)
Peter Ryan
FitzPatrick Institute of African Ornithology, University of Cape Town

Country
South Africa

Scientific Project Name
Plastic pollution and marine predators around, Greenland

Contributing Institutions
CNR-ISMAR, La Spezia (Italy)
CEFE-CNRS, Montpellier (France)

There is increasing concern about the impacts of plastics on marine ecosystems, with alarming estimates of the amount of plastic entering the sea each year. The low densities of people at very high latitudes generally lead to the perception that the polar oceans are relatively pristine. However, it has recently been suggested that the Gulf Stream is transporting large amounts of plastic into the Eastern Arctic ocean, and that sea ice in this region can be an important sink for macro and micro plastics. Less is known about the occurrence of plastics around Greenland, although seemingly high concentrations have been reported off the Eastern coast, resulting in frequent interactions with marine animals.

GLACE will offer a valuable opportunity to contrast differences in plastic loads between East and West Greenland, as well as to sample the largely unknown waters off North Greenland. During the expedition, plastic items will be sampled across the entire size spectrum, in surface waters, in the water column, on the beaches and in the sea-ice, while during navigation the amount of floating macro plastics will be evaluated by direct observations coupled with surveys of marine predators, such as seabirds and marine mammals, providing additional information about the interactions of plastics with the Arctic marine fauna, and allowing us to ascertain whether marine predators aggregate in areas with high plastic concentrations.

British Antarctic Survey

PAST ARCTIC SEA ICE EXTENT FROM ICE CORES

Category
Cryosphere

Principal Investigator (PI)
Elizabeth Thomas
British Antarctic Survey

Country
United Kingdom

Scientific Project Name
Greenland Ice Core Expedition – Climate and Sea Ice Past and Present

Contributing Institutions
Swiss Federal Institute for Forest, Snow and Landscape Research
Centre for Ice and Climate, Copenhagen (Denmark)
University of Cambridge (UK)

Sea ice is of global importance. The observed rate of decline in Arctic sea ice in recent decades, and predictions of an ice-free Arctic, have far-reaching social and economic impacts. However, systematic observations of sea ice have only begun in more recent decades. Our understanding of key processes is limited to the satellite (post-1979) era, limiting our understanding of decadal to centennial scale variability. In this project, we will provide much-needed reconstructions of sea ice beyond the instrumental period, placing the recently observed changes in context.

The experienced international team will drill shallow (20-50 m) ice cores from coastal Greenland as part of GLACE. The remote sites offer the best possibility of capturing past sea ice variability but they must be visited soon; the valuable records are at risk of meltwater damage as surface temperatures increase. We will measure a suite of chemical species contained in the ice cores to reconstruct past sea ice extent, surface temperature, snow accumulation, atmospheric circulation and surface melt. In addition, the team will install automatic weather stations in the remote Northern coastal regions to connect with a network of observational records, recording Greenland's current climate.

ETH Zurich

WATER AND TRACE ELEMENTS IN AIR, SNOW AND ICE

Category
Atmosphere

Principal Investigator (PI)
Heini Wernli
ETH Zurich

Country
Switzerland

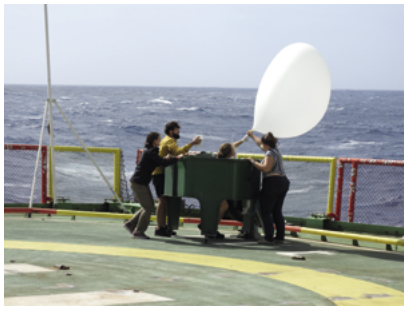
Scientific Project Name
Dynamics of atmospheric water and trace element cycles

Contributing Institutions
EPF Lausanne (Switzerland)
Eawag (Switzerland)
University of Bergen (Norway)
AWI Bremerhaven (Germany)

Transient weather systems determine the atmospheric transport of moisture and trace elements. In particular, these weather systems drive the uptake of moisture from the ocean, its long-range transport in the atmosphere, and the formation of clouds, rain and snow. These processes are all particularly intense and complex near Greenland, and they have far-reaching consequences for polar ocean dynamics, the mass balance of Greenland's ice sheet and the atmospheric cycling of trace elements. This primarily meteorological project aims at improving the understanding of these processes by observing the vertical structure of the polar atmosphere with balloon soundings, examining near-Greenland precipitation with a radar, and measuring stable water isotopes in water, in air, sea and ice. In addition, the project analyses trace elements in water samples with a global health impact, i.e., the essential element selenium (Se) and the toxic element arsenic (As).

The stable water isotopes are very useful to characterise the water cycle as they record how water molecules evaporate from the ocean, are transported over thousands of kilometres in the atmosphere, condense into water droplets in clouds, freeze and form snowflakes, and eventually are deposited in Greenland ice.

The expected outcome of this project is a unique dataset of water and trace element information near Greenland, which leads to an improved understanding of how different cycles in the Earth's system are interacting.



RESEARCH VESSEL AND ICEBREAKER

AKADEMIK TRYOSHNIKOV	50 LET POBEDY
Itinerary **Kiel to Kiel**	Itinerary **Northern Greenland only**
Type **Russian scientific diesel-electric research vessel**	Type **Russian Arktika-class nuclear-powered icebreaker designed to break through ice up to 5 metres (16 ft) thick**
Length **133.6 m**	Length **159.6 m**
Breadth **23.25 m**	Breadth **30 m**
Built in **2012**	Built in **2007**

IMPRESSUM

Graphic design & infographs
Plates-Bandes communication

Photography
Koni Steffen/WSL,
Principal Investigators,
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