Field sites

- Brønlundhus
- Svalbard
- Qaanaaq
- Longyearbyen
- Greenland
- Abisko
- Zackenberg
- Disko
- Qajaq
- Kangerlussuaq
- Nuuk
- Sermilik
- Narsarsuaq
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The period running from September 2019 to August 2020 is “a year of continuous measurements” at CENPERM sites near the Arctic Station, Disko Island, West Greenland. The formation of this long period of measurements is an important step in upscaling growing season measurements to cover year-round assessments of not only net greenhouse gas emissions and consumptions but also to quantify carry-over effects of off-season events (e.g. a warm winter spill) on growing season processes.

Such processes may include soil warming, weathering rates and plant growth. The effects of “warm winter spells” is the topic of the last CENPERM funded PhD-project. Therefore, in 2019 heating cables were installed at sites close to Arctic Station to enable warming measurements of the soil during a short period at Easter 2020.

Scaling of measurements to year-round greenhouse gas budgets has also been a theme of several 2019 publications. As described in the Highlights of 2019 (page 6), one study focussed on an ecosystem model to explain seasonal trends in the exchange of CO₂ from well-drained tundra at Disko in West Greenland. A second study was a multi-site circumpolar international collaboration project comparing non-growing season C fluxes across the Arctic. Both studies show how import winter processes are to assess annual C budgets and suggest that projections of long-term ecosystem C storage need an improved understanding of the environmental feedback mechanisms controlling winter processes.

CENPERM members and collaborators have been present in many forums, workshops and conferences in 2019. Our data collection, now spanning more than 7 years, provides us with unique opportunities to describe and to model long-term changes of Arctic ecosystems with a combination of summer and winter warming processes. A warm thank to all CENPERM members – former and current – for being ambitious, hardworking and in the same time creating a fun and team-spirit-feeling in Copenhagen as well as in the field in Greenland. I can only look forward to next year.

Copenhagen, March 2020

Bo Elberling

Photo: Martin Nielsen
Visions and aims

Center for Permafrost

CENPERM integrates multidisciplinary research of biogeochemical and physical processes in a “climate-vegetation-soil-microorganism-permafrost” approach in transects across the major climate zones of Greenland. New insights in permafrost dynamics will improve the quantification and predictions of changes in carbon and nitrogen pools and greenhouse gas fluxes from arctic ecosystems.

At Center for Permafrost (CENPERM), we study the consequences of climate changes in arctic ecosystems and address knowledge gaps in biogeochemical elemental cycles, which are related to current and future ecosystem responses. Our fundamental research goals and ambitions have been addressed through an interdisciplinary approach initiated in 2012, and has resulted in a combination of field manipulation experiments across sites in Greenland, as well as laboratory experiments linking physicochemical changes to biological adaptations and climatic feedbacks. The measurements are designed for testing and developing existing ecosystem models to reduce current uncertainties when simulating greenhouse gas emissions and ecosystem responses to climate change and land use management.

CENPERM uses a multi-site approach in which experimental work and measurements are made across major climate zones in Greenland. This allows a combination of site-specific, process-based investigations and upscaling along climate transects relevant for predicting regional trends in e.g., greenhouse gas (GHG) emissions.

The main aims for CENPERM are

1) to continue detailed measurements at experimental plots in Greenland with a focus on process understanding of the long-term effects of climate change treatments,

2) to quantify the role of landscape processes for elemental cycles across Greenland with a focus on water and energy balance, inorganic and organic nitrogen and carbon interactions and fluxes,

3) to feed data into detailed process-based models applied at plot and landscape scale,

4) to bridge these simulations with large-scale ecosystem modeling across Greenland, representing climate gradients relevant to the wider Arctic area.

The core funding for CENPERM comes from a Centre of Excellence grant (2012–2022) from the Danish National Research Foundation.

Snowfence in action in Blæsedalen, Disko Island, West Greenland. Photo: Bo Elberling
In 2019 two publications from CENPERM highlighted the importance of year-round measurements of carbon (C) fluxes. One study is based on detailed field and model work from the CENPERM key site at Disko in West Greenland; the other study is a multi-site circumpolar international collaboration project comparing non-growing season C fluxes. Both studies address the importance of winter (or non-growing season) on the annual C budget and suggest that projections of long-term ecosystem C storage also rely on environmental controls on winter processes.

1. Terrestrial carbon cycling in the high Arctic tundra depends on ecosystem responses to climatic changes and associated changes in environmental conditions. However, only a few studies have aimed to quantify long-term carbon budget in the high Arctic tundra, simply due to lack of sufficient measurements. Thus, it remains unclear to what extent Arctic tundra ecosystems currently act as CO$_2$ sources or sinks or if they are in balance. In Agricultural and Forest Meteorology, Wenxin et al., (2019) were the first group to use year-round eddy CO$_2$ flux measurements in West Greenland to calibrate and validate a process-oriented model (CoupModel). Based on year-round CO$_2$ fluxes and soil/plant characteristics, the CoupModel has succeeded in characterizing seasonal patterns of CO$_2$ fluxes, mimicking underlying ecosystem processes and quantifying an annual C budget.

The seasonal patterns of photosynthesis and soil respiration were described using response functions of the forcing atmosphere and soil conditions. The results show that total photosynthesis corresponds to -202 ± 20 g C m$^{-2}$ yr$^{-1}$ with ecosystem respiration of 167 ± 28 g C m$^{-2}$ yr$^{-1}$, resulting in a net ecosystem exchange of -35 ± 15 g C m$^{-2}$ yr$^{-1}$. The carbon loss through respiration was mainly due to decomposition of near-surface organic matter newly derived from plants. A year with an anomalously deep snowpack and hence warmer soils in late winter due to the insulating capacity of snow shows a three-fold increase in the rate of ecosystem respiration in the non-growing season compared to other years. Due to the high CO$_2$ emissions during that winter, the annual budget results in a marked reduction in the CO$_2$ sink. Snow depth, soil moisture and growing season temperatures were identified as important environmental variables, which influence seasonal rates of gas exchange.

2. Recent warming in the entire Arctic region has been amplified during the winter. This greatly enhances microbial decomposition of soil organic matter and subsequent release of carbon dioxide (CO$_2$) during the non-growing seasons. But the amount of carbon released as CO$_2$ in winter has not been quantified across the entire Arctic region. In Nature Climate Change, Natali et al., (2019) used regional in-situ observations of CO$_2$ flux from Arctic and boreal soils to assess current and future winter carbon losses from the northern permafrost domain. A contemporary mean loss of 1,662 TgC per year has been estimated from the permafrost region during the winter season (October–April). This loss is greater than the average growing season carbon uptake for the region. Extending model predictions to warmer conditions up to 2100 indicates that winter CO$_2$ emissions will increase 17% under a moderate mitigation scenario (RCP 4.5) and 41% under a business-as-usual emissions scenario.
scenario (RCP 8.5). Results provide a baseline for winter CO$_2$ emissions from northern terrestrial regions and indicate that enhanced soil CO$_2$ loss due to winter warming may offset growing season carbon uptake under future climatic conditions.
To CENPERM publikationer fra 2019 understreger vigtigheden af at måle både optag og frigivelse af kulstof (C) året rundt i arktiske økosystemer. Det ene studie er baseret på et detaljeret felt- og modelarbejde fra CENPERMs primære feltområde på Disko-øen i Vestgrønland. Det andet studie tager udgangspunkt i et internationalt forskningsprojekt, som sammenfatter målinger af kulstofbalancen fra lokaliteter over hele Arktis. Begge undersøgelser dokumenterer nødvendigheden af målinger uden for den egentlige vækstsæson (den lange vinter) for opgørelsen af det årlige C-regnskab. En fremkrivning af resultaterne viser, at prognoser for langtidslagring af C i arktiske økosystemer i høj grad er bestemt af processer netop om vinteren.


Baseret på disse CO₂-målinger og analyser af jord og plantesystemet har modellen vist sig at være velegnet til at karakterisere årstidsafhængige variationer i både optag og frigivelse af kulstof samt de grundlæggende økosystemprocesser, herunder båder fotosyntese og jordrespiration. Resultaterne viser, at den samlede fotosyntese svarer til et CO₂ optag på -202 ± 20 g C m⁻² yr⁻¹, mens frigivelsen af CO₂ via økosystemrespiration er 167 ± 28 g C m⁻² yr⁻¹. Det medfører et netto kulstoftag på 35 g C m⁻² yr⁻¹. Kulstoftabet skyldtes hovedsagelig nedbrydning af organisk stof fra planter nær overfladen og ikke fra ældre kulstofpuljer i de dybere jordlag. Et år med et usædvanlig tykt isolerende snedække og dermed varmere jord sidst på vinteren viser dog en tredobling af kulstoftabet uden for vækstperioden sammenlignet med øvrige år. Det betyder for det pågældende år, at netto CO₂-optaget er stærkt reduceret. Resultaterne viser hvor følsom kulstofbalancen er i forhold til variationer i klimaet, ikke mindst i forhold til variationer i snedybder, jordfugtig og temperatur.

med et varmere klima frem til 2100 tyder på, at CO₂-emissionen om vinteren vil vokse med 17 % i et moderat scenarie for en klimafremskrivning (RCP 4.5) og med 41 % i et uændret emissionsscenarie (RCP 8.5).

Resultaterne angiver en basislinje for vinter-CO₂-emissioner fra nordlige terrestriske regioner og indikerer, at et forøget CO₂-tab fra jorden på grund af vinteropvarmning kan ændre den samlede kulstofbalance på sigt.
Nitrogen released from thawing permafrost and plant growth

by Bo Elberling & Anders Michelsen, professors, CENPERM, University of Copenhagen

The carbon (C) balance of the ice-free part of the Arctic relies on a balance of respiration by organic matter releasing CO$_2$ to the atmosphere and the fixation of atmospheric CO$_2$ due to plant growth: two very large C fluxes on a global scale. Both fluxes tend to increase with the current projections for a warmer climate in the Arctic. An important question is, therefore, how the C balance will vary across the Arctic in the decades to come. The balance seems very much linked to nitrogen, as nitrogen stored in the permafrost may become biologically available for plants in the future and thereby link permafrost thawing and plant growth.

Plant growth in the Arctic is limited by a short growing season and in most places by water and nitrogen (N). Addition of N in experiments across the Arctic has documented significant and positive growth responses to increasing N availability, although phosphorus and other nutrient elements may also be important.

Several hundred permafrost samples have been analyzed for the content of inorganic nitrogen (nitrate and ammonium). Surprisingly, most permafrost samples have higher concentrations of ammonium than the active layer and in some cases very high concentrations. This is particularly the case for samples just below the
permafrost table, which also are the ones most likely to thaw in the near future. That means that thawing permafrost can be an important source of plant-available N\(^1\).

This source of N is only relevant for plant growth if plant roots can reach the depth where N is being released and can compete with microbes. To study plant roots, we have installed minirhizotrons, which are transparent tubes inserted into the soil to enable sequential scanning of root growth along the soil profile. This is to quantify how root growth varies across the growing season for different vegetation types and for a range of warming treatments (warmer winter and summer conditions). The conclusion is that roots tend to grow longer and thinner in response to warming\(^2\). Hence, it is likely that N sources from thawing permafrost are available for plant growth.

The work has been followed up by the addition of labelled N at the permafrost table at three locations in Greenland. Soil and plants have subsequently been sampled and analyzed for the amount of labelled N to quantify how efficiently labelled N has been incorporated in soil, microbes, roots and leaves. Across sites in Greenland, it is evident that plants are able to take up labelled N at the permafrost table (as deep as 90 cm) and incorporate it in the plant biomass. It is also evident that plant species differ in their ability to utilize the N source from thawing permafrost. Not surprisingly, plants with a deeply penetrating root system are the best at utilizing the N source at the permafrost table. That also means that an extra N source from thawing permafrost may result in a shift in plant competition and long-term changes in vegetation composition.

The Arctic tundra is also anything but flat. In fact, the undulating nature of most of the landscape means that N released from one part of the landscape may very well move with meltwater to lower parts of the landscape and here result in a positive response in plant growth. Such coupling of N release from thawing permafrost and positive responses of plant growth downstream has not been reported yet. But preliminary results suggest that lateral N fluxes can be important for the spatial distribution of plant growth responses and corresponding greenhouse gas fluxes in the receiving landscape depressions.

Current studies in Greenland are based on site-specific observations, but scaling to larger regions is important. Greenland is an example of very contrasting environmental conditions, including permafrost and water balance, from South to North. Permafrost is widespread and precipitation is low in the northern part of Greenland. This means that N release from thawing permafrost will not immediately be leached from some ecosystems but will rather be available for plant uptake. In the southern part of Greenland, permafrost is found more sporadically and the markedly higher precipitation may result in N being leached out and less available for plant uptake. In conclusion, the link between N released from thawing permafrost and plant growth can be critical for quantifying the greening of the Arctic in response to climate changes, and large-scale variations across Greenland are expected.


Publications


Mörsdorf, M.A., Baggesen, N.S., Yoccoz, N.G., Michelsen, A., Elberling, B., Ambus, P.L., Cooper, E.J. (2019). Deepened winter snow significantly influences the availability and forms of
nitrogen taken up by plants in High Arctic tundra. Soil Biology & Biochemistry 135, 222-234.


Conference proceedings

Other publications


Invited talks


Rasmussen, L.H. (2019). Belowground responses to aboveground changes - biogeochemical responses of two Arctic ecosystems in the face of gradual environmental change vs. extreme summers. European Geoscience Union (EGU) General Assembly, Vienna, Austria, April.


Presentations at conferences


CENPERM continued its series of weekly talks at the Department of Geosciences and Natural Resource Management. These seminars were also held for PhD students and postdocs to present specific parts of their work, to create a forum for sharing of knowledge, problems, and solutions within the Center. This process has enabled CENPERM members and contributors to share important research across academic levels and backgrounds.

Examples of outreach

Electronic and social media


Press


Other

Elberling, B.: “Klimaforandringer i Arktis”. Public lecture at Arktisk Festival 2019. Copenhagen Nov. 2-3,

Michelsen, A.: Presentation of climate change related field experiments, methodology and results. Demonstration of field experiments for tourists on Disko Island, Greenland.


**CENPERM weekly seminars**

Jan. 31.
NEW YEAR reception and decoration of the CENPERM Tree of Wisdom.

Feb. 21
**Tao Li**, Postdoc, BIO/CENPERM. “The smell of the Arctic change: using plant volatiles to explain insect range expansion”.

Feb. 25.-27.
CoupModel workshop.

Mar. 7.
Casper T. Christiansen, Postdoc, NORCE Norwegian Research Centre AS. “First estimate of pan-Canadian permafrost dissolved organic matter pool sizes and potential bioavailability”.

Cecilie Skov Nielsen, PostDoc, Swedish University of Agricultural Sciences, Umeå, Sweden. “What can we learn from studying the carbon isotopic signature of peatland CO₂ and CH₄ fluxes”?

Mar. 21.
**Ylva Sjöberg**, Associate professor, CENPERM, IGN. “Representing coupled changes in permafrost and hydrology in site-specific modeling”. Inaugural lecture.

Mar. 28.

Apr. 4.

May 11.
Thomas Ingeman-Nielsen, Associate professor, DTU. “Engineering challenges in Qaanaaq”.

May 16.
Fieldwork 2019. Planning and coordinating Coordinator: Anders Priemé

May 23.
Annual CENPERM summer event: Excursion to Greenland at Louisiana.

Sep. 19.
Highlights from the CENPRM field campaign 2019.
Oct. 3.
Seminar on CENPERM web communication.

Oct. 10.
Wenxin Zhang, Assistant professor, CENERM/Lund University. “Modelling carbon budget of snow fence treatments in a dry heath ecosystem in Blæshedalen”.

Oct. 31.
Michele Citterio, Senior Scientist, Ph.D., GEUS. “Permafrost degradation on steep bedrock slopes”.

Nov. 7.
Jonathan von Oppen, Candice Power, Oliver Baines and Signe Normand, University of Aarhus, Denmark: Three PhD projects investigating the relationship between microclimate and plant communities, drivers of shrub growth and recruitment.

Nov. 14.
Wenyi Xu, PhD student, CENPERM. “Impact of increased snow cover on N cycling in contrasting Arctic tundra soils”.

Nov. 21.
Three CENPERM PhD projects:
Emily Pickering Pedersen, PhD student, CENPERM/BIO: “Plant competition for nutrients: effects of increased precipitation and reduced phosphorus limitation in a low arctic heath ecosystem”.
Jolanta Rieksta, PhD student, BIO - Terrestrial Ecology Section, BVOC group/CENPERM: “Insect herbivory – a hidden contributor to plant volatile emissions in the high latitudes”.
Tihomir Simin, PhD student, BIO - Terrestrial Ecology Section, BVOC group/CENPERM: “Terpenoid emission in tundra shrubs – dependence on species characteristics and the environment”

Nov. 28
Jana Voriskova, Postdoc CENPERM. “Bacterial and fungal response to simulated permafrost thaw under aerobic and anaerobic conditions”.

Dec. 5
Toke Høye, Senior scientist, Aarhus University. “A computer vision of the drivers and consequences of species interactions”.

Measurements of water table near CENPERM snow fence experimental site in Blæshedalen (Disko Island, West Greenland) Photo: Bo Elberling
CENPERM’s activities in 2019 include a number of educational efforts. These include both arctic field courses and classic university courses at the basic and advanced levels at the University of Copenhagen. In addition to course taught, a number of M.Sc. theses have been supervised (see: Ongoing research projects).

**Teaching at the B.Sc. level**

“Almen mikrobiologi”, Dept. of Biology, University of Copenhagen, autumn, A. Priemé.

“Basic arctic biology”, Dept. of Biology, University of Copenhagen, spring, R. Rinnan, A. Michelsen, B.U. Hansen.

“Biological experiments: design and analysis”, Dept. of Biology, University of Copenhagen, autumn, A. Michelsen.

“General ecology”, Dept. of Biology, University of Copenhagen, spring, A. Michelsen, R. Rinnan, H. Ro-Poulsen.

“Globale geosystemer”, Dept. of Geosciences and Natural Resource Management, University of Copenhagen, autumn, G. Schurgers.

“Important flows in society”, Dept. of Geosciences and Natural Management, University of Copenhagen, autumn, B. Elberling.

“International bachelor permafrost summer field school”, University Centre in Svalbard, Norway, summer, A. Priemé.

“Jordbundsressourcer og jordbundens miljøgeokemi”, Dept. of Geosciences and Natural Management, University of Copenhagen, spring, P. Ambus.

“Plant ecophysiology”, Dept. of Biology, University of Copenhagen, spring, H. Ro-Poulsen, A. Michelsen, K. Rousk.

**Teaching at the M.Sc. level**

“Advanced bacteriology 2”, Dept. of Biology, University of Copenhagen, autumn, A. Priemé.

“Advanced Soil Science and Stable Isotope Geochemistry”. University of Copenhagen, spring. P. Ambus.

“Arctic biology”, Dept. of Biology, University of Copenhagen, spring, R. Rinnan, A. Michelsen, A. Priemé.

“Climate change and biogeochemical cycles”. Dept. of Biology, University of Copenhagen, autumn, R. Rinnan, K. Rousk, P. Ambus, G. Schurgers.
“Climate change - an interdisciplinary challenge”. Dept. of Geosciences and Natural Management, University of Copenhagen, autumn, R. Rinnan, T. Friborg, G. Schurgers, A. Kroon.

“Coastal geosciences”, Dept. of Geosciences and Natural Management, University of Copenhagen, autumn and winter, A. Kroon.

“Ecological modelling”, Dept. of Geosciences and Natural Resource Management, University of Copenhagen, spring, G. Schurgers.


“Experimental design and statistical methods in biology”, Dept. of Biology, University of Copenhagen, spring, A. Michelsen, R. Rinnan.


“Methodology and sampling in environmental management”, Dept. of Biology, University of Copenhagen, spring, A. Michelsen.

“Molecular microbiology I”, Dept. of Biology, University of Copenhagen, autumn, A. Priemé.

“Terrestrial ecosystem processes and global change”, Dept. of Biology, University of Copenhagen, spring, R. Rinnan, A. Michelsen, H. Ro-Poulsen, K. Rousk.

**Teaching at the Ph.D. level**


“Biogenic volatiles – exchange at different scales and interactions with ecosystem processes”, Nov. 4-8, University of Copenhagen, R. Seco, R. Rinnan (organizer).

Ongoing research projects & graduate students

Like previous years, a special Master theses workshop was held in March with discussion and presentations of projects in progress. A number of the master students participated in the CENPERM fieldwork in Greenland and northern Sweden.

**Postdoc and Assistant Professor projects**

D’Imperio, Ludovica. Postdoc:  
“Soil-plant interactions and greenhouse gas dynamics in permafrost-affected ecosystems”.

Koranda, Marianne. Postdoc:  
“Effects of bryophytes on soil microbial processes and N-cycling” (BryoSoil)

Kramshøj, Magnus. Postdoc:  
“Production and consumption of biogenic volatiles by arctic soils using state-of-the-art analytic method PTR-TOF-MS”.

Li, Tao. Postdoc:  
“BVOC-plant-insect interactions under climate change”.

Ravn, Nynne Rand. Postdoc:  
“Arctic soil carbon turnover controlled by experimental snow addition, summer warming and shrub removal”.

Rousk, Kathrin. Assistant Professor:  
“Climatic, ecological and molecular controls of nitrogen fixation in pristine systems”.

Seco, Roger, Assistant Professor:  
“Volatile organic compound fluxes from tundra ecosystems using the Eddy Covariance technique”, ERC Consolidator project “TUVOLU”.

Tang, Jing. Postdoc:  
“Modelling Arctic Biogenic Volatile Organic Compounds emissions and their impacts on regional air quality”.

Voriskova, Jana. Postdoc:  
“Carbon dioxide production and microbial diversity in soils across arctic landscapes”.

Westergaard-Nielsen, Andreas. Assistant Professor:  
“Mapping, scaling, and modelling permafrost and related biogeo-processes using multi-scale Remote Sensing and GIS”.

Zhang, Wenxin. Assistant Professor:  
“Modeling soil gas diffusion, treatment effects on carbon fluxes, root dynamics and methane dynamics in Blæsedalen ecosystems”.

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Ongoing PhD projects at CENPERM 2019

Baggesen, Nanna:
“Emissions of biogenic volatile organic compounds (BVOCs) from a subarctic heath ecosystem, using a PTR-MS that allows for diurnal measurements on a fine time resolution”. Supervisor: Riikka Rinnan.

Danielsen, Birgitte Kortegaard:
"Arctic subsurface gas dynamics”. Supervisor: Bo Elberling, co-supervisors Riikka Rinnan and Guy Schurgers.

Fenger-Nielsen, Rasmus:
“Predicting and mapping environmental threats to archaeological sites in Greenland under current and future climate conditions”. Supervisors: Bo Elberling, Jørgen Hollesen and Aart Kroon.

Kylborg, Sarah E.:
“UV-stimulated nitrous oxide emissions”. Supervisor: Per Ambus.

Pedersen, Emily Pickering:

Permin, Aya Foged:

Rasmussen, Laura Helene:
“Impact of soil nitrogen availability and snow depth on below-ground methane dynamics in the freezing and thawing landscape”. Supervisor: Bo Elberling, co-supervisors: Anders Michelsen and Per Ambus.

Rieksta, Jolanta:
Effects of insect herbivory and warming on BVOC emissions in the Arctic”. Supervisor: Riikka Rinnan.

Simin, Tihomir:
“Improved quantification of relationships among canopy temperature, plant phenology, species characteristics and BVOC emission under varying environmental conditions”. Supervisor: Riikka Rinnan.

Xu, Wenyi:

Yun, Hanbo:

Zastruzny, Sebastian:
“Quantifying the release of nutrients from changing permafrost”. Supervisor: Bo Elberling, co-supervisor: Thomas Ingeman-Nielsen, DTU.
M.Sc. projects supervised at CENPERM 2019

Completed MSc projects: 12

Andersen, Emil Alexander Sherman: "Vegetation analysis and soil biogeochemical characteristics in the Nuuk region, Greenland in relation to archaeological sites and climate change". Supervisors: Anders Michelsen, Bo Elberling and Rasmus Fenger-Nielsen.


Freendrup, Laura Lønstrup: "The impact on the nitrogen cycle in an arctic tundra with a changing climate". Supervisor: Per Ambus.


Gough, Isabelle Victoria Margaret: "Microbial community responses to freeze thaw cycles in Arctic soils. Supervisors: Anders Priemé and Eveline Krab (Swedish University of Agricultural Sciences).


Larsen, Laura Bjørnholt: "Roots in a dry Arctic tundra - Effects of increased winter precipitation". Supervisor: Bo Elberling.


Mariager, Trine: "Microbial communities on arctic shrub leaves and their effect on volatile emission". Supervisors: Riikka Rinnan and Anders Priemé.

Ranniku, Reti: "Methane oxidation in soils from sub-Antarctic South Georgia Island". Supervisors: Bo Elberling and Ludovica D’Imperio.


Ongoing MSc projects: 17

Aeppli, Laurids Christian Brogaard: “Insect herbivory induced emission of BVOC from birch and willow in the subarctic”. Supervisor: Riikka Rinnan.

Christensen, Maj Paornak Sofie D.: "Nitrogen uptake by arctic heath plants in response to enhanced precipitation and phosphorus input in West Greenland". Supervisors: Anders Michelsen and Emily P. Pedersen.

Jacobsen, Cathrine Kallestrup: “Plant ecophysiology, carbon cycling and vegetation responses at snowbed gradient, Disko”. Supervisor: Anders Michelsen, Kari Anne Bråthen, University of Tromsø, Norway.


Matzen, Mikkel Sillesen: “The linkage between, canopy surface temperature, BVOC emission and the present of ozone, nitrogen oxides and particles during a whole growing season in an subarctic wetland”. Supervisors: Riikka Rinnan and Andreas Westergaard-Nielsen.


Ryde, Amalie: “Herbivore-induced volatile organic compounds, and changes through an elevation gradient, induced by winter moth on mountain birch in the Subarctic, Tromsø”. Supervisors: Riikka Rinnan and Elizabeth Jakobsen Neilson.


Stevnsvig, Anna Marie: “Description of vegetation succession in Denmark based on analysis of plant macrofossils from sediment cores covering the Late glacial and Holocene”. Supervisors: Anders Michelsen and Peter Steen Henriksen, Nationalmuseet, Copenhagen.


Research activities at CENPERM are linked to a number of well-established international arctic networks. These cooperation agreements are supplemented by a strong affiliation to internationally recognized researchers. CENPERM has continuously extended the international Arctic network, which is linked through several projects. Currently, CENPERM participates in several pan-Arctic networks as INTERACT, the Permafrost Carbon Network and ICOS (Integrated Carbon Observation System – Research Infrastructure).

Cooperation in a national and Greenlandic context is ensured within Danish and Greenlandic networks as Greenland Ecosystem Monitoring (GEM) and through ongoing projects with the Geological Survey of Denmark and Greenland (GEUS), University of Aarhus, Danish Meteorological Institute (DMI), the Centre for Arctic Technology – Technical University of Denmark (ARCTEK), the National Museums in Denmark and Greenland, Agricultural Consulting Services (Upernaviarsuk research station), Greenland Survey (Asiaq) and Greenland Institute of Natural Resources.

**International research partners and co-operators**

Adam Mickiewicz University, Poznan, Poland: A. Buchwal.

Agriculture and Agri-Food, Ottawa, Canada: E. Gregorich. Shared fieldwork, North Greenland.

Bonn University, Germany: S. Weijers. Climate impacts on Cassiope tetragona growth and isotopic composition.


Canada’s Nuclear Waste Management Organization (NWMO).

Eidgenössische Technische Hochschule Zürich, Schweiz: T. Crowther.


Gothenburg University, Sweden: R. Björk. Permafrost samples and scientific publications.


Los Alamos National Laboratory, USA: C. Andresen, Permafrost impacts on hydrology.

Pacific Northwest National Laboratory, Biological Sciences Division, Richland, WA, USA: J. K. Jansson.

Northern Arizona University and OEB Harvard University, USA: Analyzing phenocam images. Scientific publication.

Russian Academy of Science, Russia: M. G. Akperov. Arctic cyclones. Scientific publications.

Radioactive Waste Management (RWM). United Kingdom.

Stanford University, USA: A. Ahlström. Modelling large-scale C cycle.

State Key Laboratory of Frozen Soil Engineering, Lanzhou, China.


Swedish Nuclear Fuel and Waste Management Company (SKB).


UiT Arctic University of Norway, Tromsø, Noway: E. Cooper. Snow fence studies Svalbard.


University Centre in Svalbard (UNIS), Norway: P. Bronken Eidesen and H. H. Christiansen. Permafrost cores and scientific publications.


University of Anchorage, Alaska, USA: Jeff Welker. Climate impacts on Cassiope tetragona growth and isotopic composition.

University of Bergen, Norway: L. Øverås.

University of Boulder, Institute for Arctic and Alpine Research (INSTAAR), Colorado, USA: I. Overeem, K. Barnhart. Coastal changes in Greenland.

University of Eastern Finland, Department of Environmental Science, Finland: M. Kivimäenpää. Sample treatment, light and scanning electronmicroscopy.

University of Edinburgh, School of GeoSciences, UK: I. Myers-Smith, S. Angers-Blondin. Pan-arctic shrub growth meta-analysis.
University of Helsinki, Department of Forest Sciences, Finland: K. Karhu. Climate impacts, soil geochemistry.

University of Lund, Sweden: B. Smith, P. Miller, M. Berggren. Biogeophysical feedbacks on pan-Arctic regions. Model development, Model code, scientific publications.


University of Oslo, Department of Geosciences, Norway: B. Etzelmuller, S. Westermann. Permafrost modelling. O. Humlum; Field work (and data analyses) of geomorphology at Disko, W. Greenland.

University of Montana, USA: F. Gilman. Disko soil microbial studies.

University of Sherbrooke, Canada: J.P. Bellenger; Nutrient limitation of nitrogen fixation in the boreal biome. Robert Bradley; Effects of N and metal pollution on N fixation.

**External funding**

Researchers within the Center have been funded by a range of research grants in 2019. Such external funding opportunities have been pursued through national and international research foundations. These external funding allows CENPERM to further strengthen research and educational activities.

**Public Danish funds**

The Danish Council for Independent Research, Sapere Aude:

The Danish Council for Independent Research, Natural Sciences:

Danish Energy Agency (Energistyrelsen):

Danish Energy Agency (Energistyrelsen):

The Danish Independent Research Fund, Sapere Aude DFF-Forskningsleder:

Danish Ministry for Research:
Independent Research Fund Denmark, Natural Sciences: “UV-stimulated nitrous oxide emissions, the ignored impact on atmospheric warming (UVwarm)”. Grant holder: Per Ambus (2018-2022): DKK 5.7 mio.


Private Danish funding


International funding


## Researchers

<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
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<tbody>
<tr>
<td>Ambus Per Lennart</td>
<td>Professor</td>
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<tr>
<td>Andersen Emil A. S.</td>
<td>Research assistant</td>
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<tr>
<td>Andersen Thorbjørn J.</td>
<td>Professor</td>
</tr>
<tr>
<td>Elberling Bo</td>
<td>Professor, Director</td>
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<tr>
<td>Frendrup Laura Lønstrup</td>
<td>Research assistant</td>
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<tr>
<td>Friborg Thomas</td>
<td>Associate professor</td>
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<tr>
<td>Hansen Birger Ulf</td>
<td>Associate professor</td>
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<tr>
<td>Hermesdorf Lena</td>
<td>Research assistant</td>
</tr>
<tr>
<td>Hollesen Jørgen</td>
<td>Senior Researcher</td>
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<tr>
<td>Kroon Aart</td>
<td>Associate professor</td>
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<tr>
<td>Larsen Laura Bjørnsholt</td>
<td>Research assistant</td>
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<tr>
<td>Michelsen Anders</td>
<td>Professor</td>
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<tr>
<td>Priemé Anders</td>
<td>Professor</td>
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<tr>
<td>Rinnan Riikka</td>
<td>Associate professor</td>
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<tr>
<td>Ro-Poulsen Helge</td>
<td>Assistant professor</td>
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<tr>
<td>Rousk Kathrin</td>
<td>Associate professor</td>
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<tr>
<td>Schurgers Guy</td>
<td>Assistant professor</td>
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<tr>
<td>Seco Roger</td>
<td>Research assistant</td>
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<tr>
<td>Sigsgaard Charlotte</td>
<td>Associate professor</td>
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<tr>
<td>Sjöberg Ylva</td>
<td>Assistant professor</td>
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<tr>
<td>Westergaard-Nielsen, Andreas</td>
<td>Assistant professor</td>
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<tr>
<td>Zhang Wenxin</td>
<td>Assistant professor</td>
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## Postdocs

<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
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<tbody>
<tr>
<td>D’Imperio Ludovica</td>
<td>Postdoc</td>
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<tr>
<td>Koranda Marianne</td>
<td>Postdoc</td>
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<tr>
<td>Kramshøj Magnus</td>
<td>Postdoc</td>
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<tr>
<td>Li Tao</td>
<td>Postdoc</td>
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<tr>
<td>Ravn Nynne Rand</td>
<td>Postdoc</td>
</tr>
<tr>
<td>Tang Jing</td>
<td>Postdoc</td>
</tr>
<tr>
<td>Voriskova Jana</td>
<td>Postdoc</td>
</tr>
</tbody>
</table>
PhD students
Baggesen     Nana     PhD student
Danielsen  Birgitte Kortegaard  PhD student
Fenger-Nielsen  Rasmus  PhD student
Kyborg      Sarah Estela  PhD student
Pedersen   Emily Pickering  PhD student
Permin      Aya    PhD student
Rasmussen  Laura H.     PhD student
Rieksta    Jolanta  PhD student
Simin       Tihomir  PhD student
Xu          Wenyi    PhD student
Yun         Hanbo    PhD student
Zastruzny   Sebastian  PhD student

Technical staff
Davie-Martin  Cleo  Laboratory manager
Ludvigsen    Søs Marianne  Laboratory technician
Madsen       Mathias  Electronics technician
Nielsen      Esben V.  Laboratory technician
Pørksen      Kent    Graphic designer
Sylvester    Gosha   Laboratory technician
Wahlgren     Maja Holm  Laboratory technician

Administration
Bjerre       Karen E.  Center administrator
The Danish National Research Foundation (DNRF) is an independent organization established by the Danish Parliament in 1991 with the objective to promote and stimulate basic research at the highest international level at the frontiers of all scientific fields. The Center of Excellence (CoE) program is the main funding mechanism, but also a number programs and initiatives have been launched specifically targeted at increasing the level of internationalization of Danish research communities.

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