VILLUM
RESEARCH STATION,
Station Nord

2016 ANNUAL REPORT

AARHUS
UNIVERSITY

Grønlands Naturinstitut
Pinngortitaleriffik · Greenland Institute of Natural Resources

VILLUM RESEARCH STATION, Station Nord
2016 ANNUAL REPORT

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VILLUM RESEARCH STATION

Photo: Bjarne Jensen.

CONTENT

WELCOME FROM THE HEAD OF THE STATION

By Professor Henrik Skov,
Scientific Head of Station

It is a great pleasure for me to present Villum Research Station, Station Nord's second annual report. The first year was characterized by the large campaign within the framework of Arctic Science Partnership. In 2016 Villum Research Station, Station Nord (VRS) hosted a series of smaller projects and the monitoring activities for the Arctic Monitoring Assessment program (AMAP).

Among the activities were studies in botanic and marine biology as well as geological studies of sediments. A description of these activities is found in this yearly report.

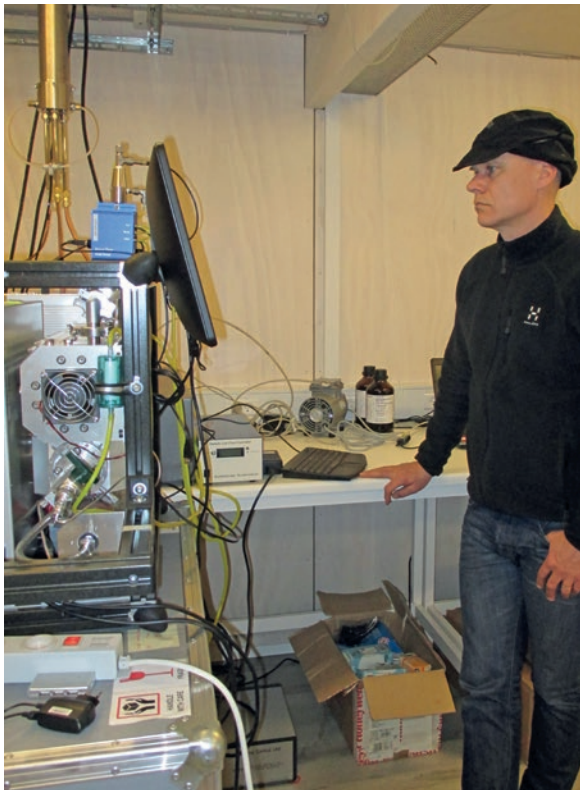
Finally, process studies of the fate of air pollutants were made and long term measurements of air pollutants, meteorology and climate.

I have enjoyed my own stay at the Station especially in the spring, where we studied the emission of elemental mercury from the snow pack and how mercury is transformed from elemental mercury to gaseous oxidized mercury and to particulate bound mercury. This study was made together with a study of the physical and chemical properties of Arctic aerosols. It is always a pleasure to work together with young scientist and I enjoyed very much this year working together with PhD student Robert Lange and master thesis students Jesper Kamp Jensen and Jesper Baldtzer

WELCOME

Air Monitoring House just after the first inlet was established. Photo: Bjarne Jensen

Jacob Klenø Nøjgaard working at the SP-AMS (soot particle aerosol mass spectrometer). Photo: Henrik Skov



Liisberg, experiencing their enthusiasm and drive, even when dealing with difficult experimental problems. The campaigns also gave me the opportunity to see how well VRS works in practice and I am very happy for the outcome. The Station is indeed very well fitted to do interdisciplinary scientific investigations. Finally, it is also nice to see that the Station hosted scientist from all over the world (Norway, Finland, Canada, Germany, Russia, South Korea among others).

The ultimate goal for all scientific investigations is to make them public through peer reviewed articles, popular scientific presentations etc. Therefore it is nice to follow the publications that are now produced from activities at Villum Research Station. I will especially mention the Article by Mikko Sipilä and co-workers who published the first article in Nature based on results from the Station. I am convinced that this is just the first article of a long series from VRS in top ranked journals.

The base for our presence in North Greenland is the collaboration with the Danish Defense (Arctic Command) running Station Nord. Without this collaboration it would be impossible to have VRS. Our activities started in a small hut in 1990 and right from the beginning we have received funding from the Danish Environmental Protection Agency to carry out monitoring of contaminant transport into the Arctic as part of the Danish contribution to the Circum-Polar monitoring program AMAP (Arctic Monitoring and Assessment Program). Therefore we have today time series going back to 1990 which represent some of the most important Arctic data in the world. With the establishment of VRS the value of the data is even higher, since they are increasingly being used by the international scientific community and have provided the basis for some of the international campaigns at VRS. For this reason the ongoing monitoring activities carried out at VRS give added value to the campaigns and other research activities carried out at VRS.

Finally, I would like to express my gratitude to VILLUM FONDEN for the large grant we were awarded and the trust you have shown us. VRS is well on its way to be a world leading research facility in high Arctic. Our ambitions are high and we can already now see the tremendous interest that the station has internationally.

VRS is run by Aarhus University and owned by Greenlandic Institute for National Resources. Therefore Jørgen Skafte and I visited the Institute in December, where we told about the activities and results in 2016 and the plans in 2017-2019. There was also a large interest from the Institute and concrete plans are made already for projects in 2017. One scientist will use one of the drones for investigation of polar bears in North Greenland and another will look for different species of seals.

View from Villum Research Station towards North over the e-pron. Photo: Christel Christoffersen

THE NEW SCIENTIFIC INFRASTRUCTURE, VILLUM RESEARCH STATION

By Henrik Skov and Jørgen Skafte

The aim of Villum Research Station (VRS) is to have a state of the art scientific infrastructure to support break through research within climate related subjects in the high Arctic. To support this aim it is established as multidisciplinary research facility.

VRS consist of three sub stations:

- Base Station: Buildings
- Mobile Station: Tents and vehicles
- Air Station: Drones and ground based remote sensors

The construction of the Base Station had the priority the first years after the grant from Villum Foundation was given. A strong team was set up consisting of Head of Construction Bent Lorentzen, Engineer Ioanna Miclaus Hansen, Coordinator of Logistic Morten Rasch and Head of the Station. In the following a short historical reading is given.

ESTABLISHING THE STATION

The grant was awarded in February 2013. All permits etc. was provided by the Greenlandic authorities during spring 2013. Immediately after the permits were provided the foundations to the houses were built during summer 2013. The construction of the houses was at the same

Researchers' House and Garage in August. Photo: Morten Rasch

time started by Venslev Byg at their facilities in Denmark, after they won the call for tender. The houses were ready for shipping to Station Nord in spring 2014. About 300 tons were shipped to Svalbard. From Svalbard all the building material was flown to Station Nord.

During six weeks in summer 2014 the house was constructed, thereafter we were a group of people who stood for the practical installations of furniture and equipment in laboratories and further were the quarters organized for living. In 2015 the buildings were inaugurated, however there were still installations to make in 2016 in order to have a full operational research station. Among others were a series of installation missing in order to do measurement of gasses and particles in the atmosphere. Thus the last particle inlet was installed in the Air Monitoring House together with two high volume samplers; one for monitoring activities and another for visitors. It has been a pleasure to see how well the houses are functioning and serves scientist working within different disciplines.

In 2016 the Mobile Station has been build up with the purchase of tents, larger snowmobiles and ATVs. The first tent has been raised and tested and all tents bought. The final Mobile Station will be able to accommodate up to 15 people both summer and winter. There will be two shelters that can be equipped for research or be used for education.

A. Loading building materials for shipping to Longyearbyen on Svalbard.
Photo: Morten Rasch

B. Off loading the dornier operated by Lufttransport.
Photo: Morten Rasch

C. Construction of the walls in the Researchers' House.
Photo: Morten Rash

D. Topping-out Ceremony.
Photo: John Lau Hansen

E. Installation of particle and gas inlets and exhaust chimneys at the Air Monitoring House.
Photo: Bjarne Jensen


A


B


C


D


E


F

A. Snow mobiles from the Mobile Station in action on the sea ice. Photo: Jesper Kamp

B. ATV's in the Garage building. Photo: Christel Christoffersen

C. Preparation of bicycle run to Air Monitoring House. Photo: Robert Lange

D. A moment of relaxation in Researchers' House. Photo: Henrik Skov

E. Chemical lap filled with samples ready for first treatment. Photo: Henrik Skov

F. Quite work in the living room in Researchers' House. Photo: Henrik Skov

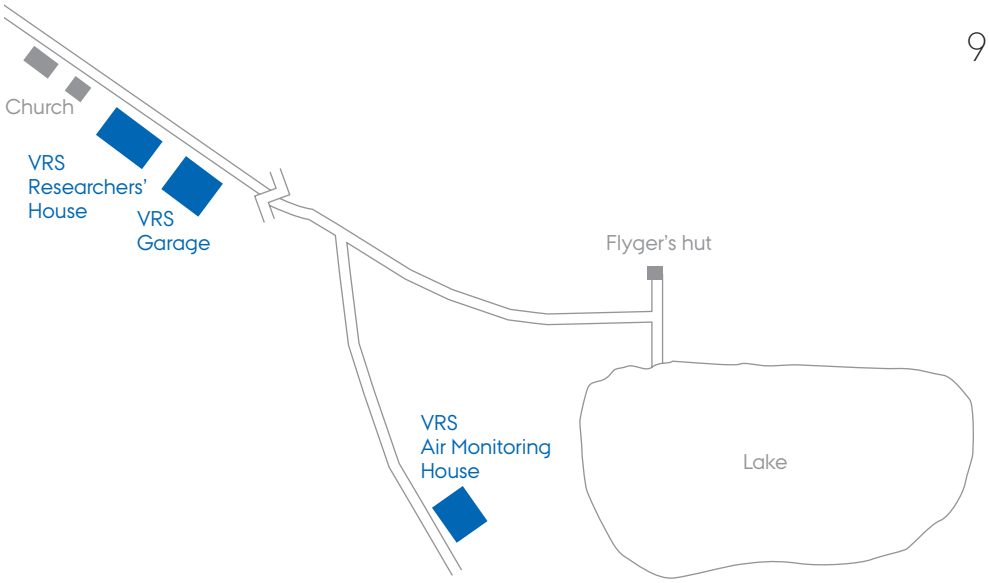
G. C17 filled with equipment and provisioning. Photo: Christel Christoffersen

Two amphibious ATVs are modified to run on snow and they will be able to transport this equipment out on the sea ice and at larger distances from VRS. It will be a new milestone for VRS, when we have the first campaign established using this substation.

The structure of last sub-station is also visible now. A small drone (eBee) was bought already in 2014 in order to take detailed pictures of Princess Ingeborg's Peninsula, where VRS is located. The first of three larger drones was purchased in 2016. This drone has been equipped with a LIDAR system together with an autopilot and advanced communication systems. This makes it possible to study sea-ice in details and to operate the drone in high Arctic areas outside the range of mobile phones and beyond line of sight distances. The final tests of this drone will be conducted in Denmark during the first six months of 2017, followed by the first flights and investigations in Greenland in the summer.

In order to operate at VRS it has been necessary to develop a strong logistic, so that scientist, instruments and other equipment easily are transported in and out of VRS. Therefore an important part of the establishment of VRS is the establishment of a strong logistical unit that can support teams of scientists working on the research station at Station Nord or are using the other platforms. There is now established collaboration with research institutions from other countries also having extensive experience in working in the Arctic. Therefore VRS will in future be able to benefit from those institutions' infrastructure, for example through the mobilization of aircrafts and helicopters to northern Greenland. This collaboration is mediated through a new webpage (www.isaaffic.org). There are already plans for joint ventures in 2017 and 2018 due to this cooperation.

AIR QUALITY MEASURED AT VILLUM RESEARCH STATION SINCE 1990



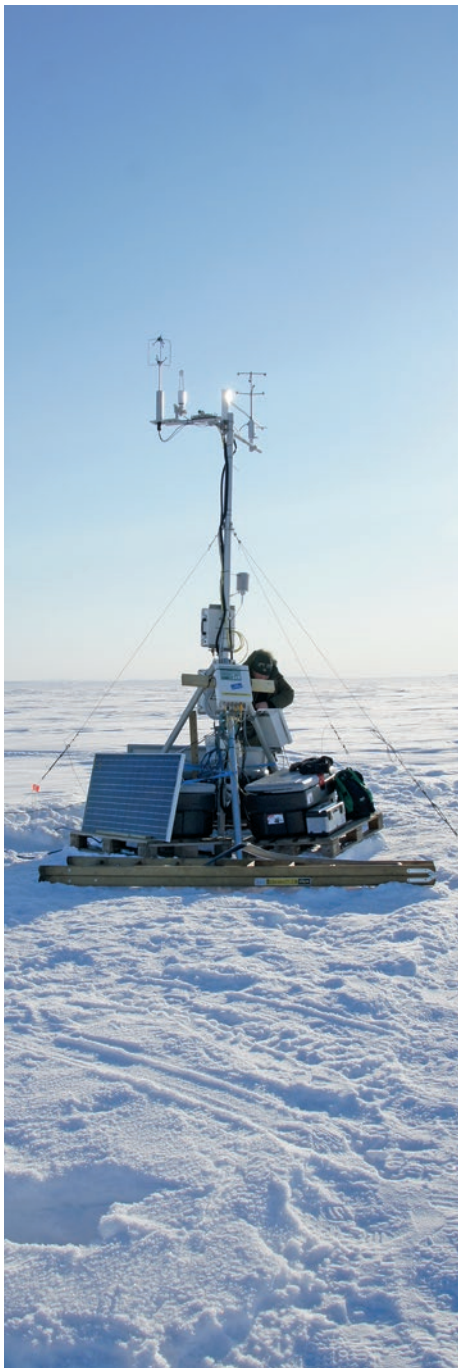
By Andreas Massling

AIR POLLUTION

In 1990 a filter pack sampler was installed at Station Nord. The filter pack sampler has been operated from 1990 – 1997 at the Longwave hut (located at the northern end of the runway), from 1995 – 2017 at Flyger's hut (about 2.5 km south of the military camp) and will be installed from 2017 and ongoing at the Air Monitoring House (also about 2.5 km south of the military camp, but in a distance of about 300 m from Flyger's hut).

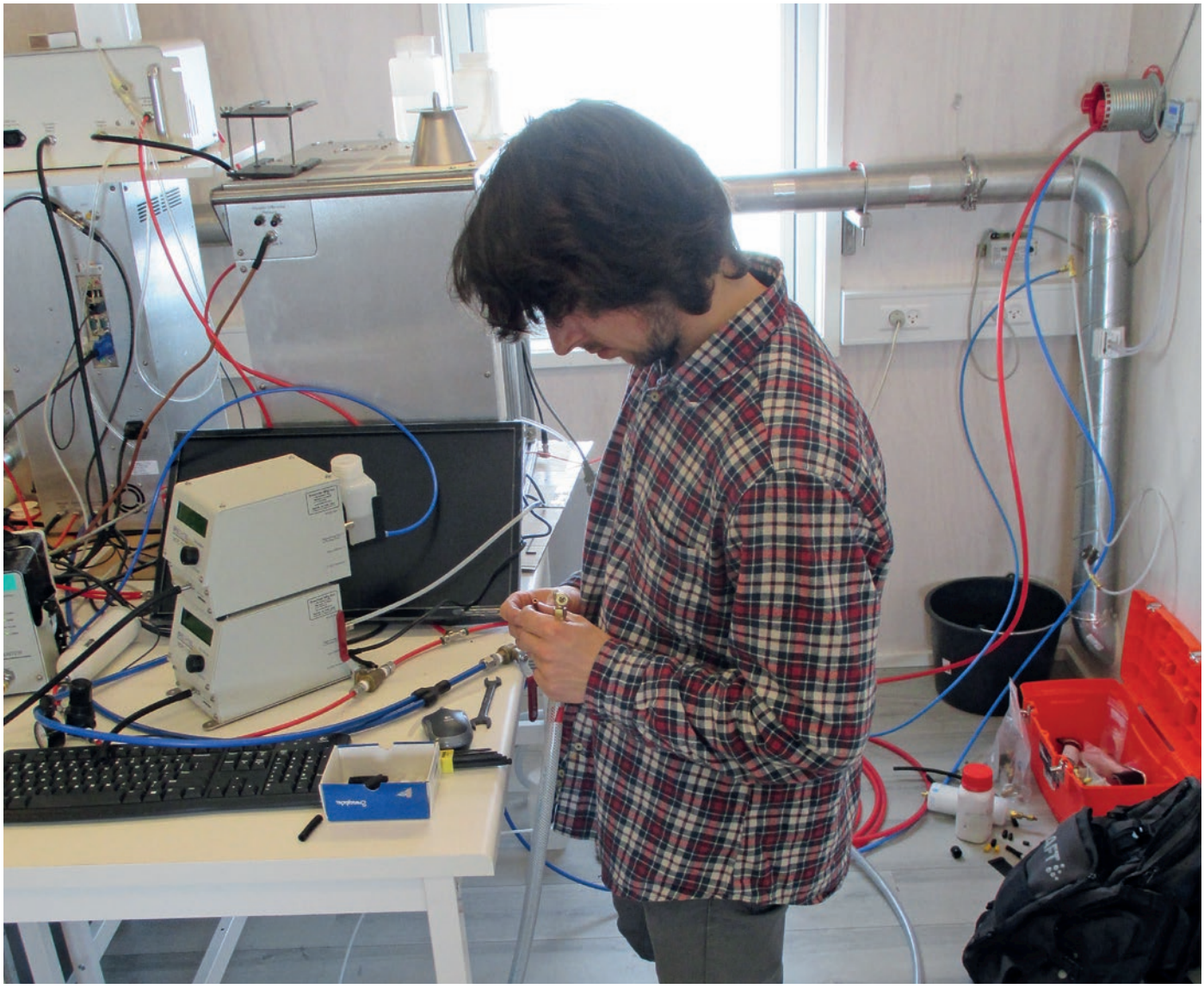
The purpose of this filter pack sampler was to collect particulate mass and gasses on a monitoring base. The particle filters were analysed for many different chemical species including sulphur dioxide and sulphate. From 1990 to 2015, the filter pack sampler was located at Station Nord at two different measurement huts, which both were located outside the camp in order to avoid local pollution of the samples. The boom with the filter holders was installed about 4.5 meter above the roof of the measurement huts representing surface measurements in the boundary layer. From 2002 to 2007 the sampler was relocated to Nuuk in Southeast Greenland explaining the data gap in Figure 3.1.

Air Monitoring House. Photo: Christel Christoffersen



Flux system for measuring fluxes of carbon dioxide and methane. Photo: Christel Christoffersen

PhD student Robert Lange works on the HTDMA (Hygroscopicity Tandem Differential Mobility Analyzer) for measuring hygroscopicity of aerosols. Photo: Henrik Skov



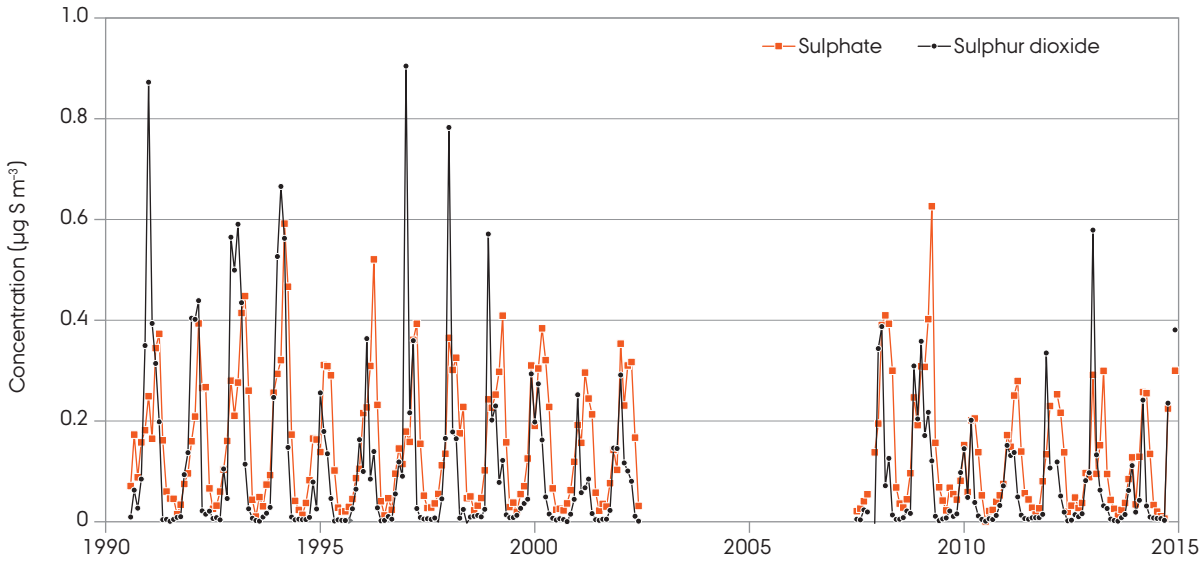


Figure 3.1. Time series of monthly concentrations of S in sulphur dioxide and sulphate measured at Villum Research Station (VRS) in North Greenland during the observation period from 1990 to 2015.

Figure 3.2.
Arctic haze event observed at Villum Research Station (VRS) in North Greenland during spring 2015.
Photo taken by Webcam

In this figure, the monthly mass concentrations of sulphur dioxide and sulphate in units μg S m^{-3} are presented over a period of 26 years.

The sulphate as well as the sulphur dioxide concentrations show a typical seasonal pattern which is characteristic for long range transported atmospheric pollutants in the high Arctic. The pattern is representing the appearance of Arctic haze, a phenomenon that has been observed during previous studies at the same location. Sulphur dioxide is a major precursor gas for the formation of sulphate aerosol. In principle, the emission of sulphur dioxide is related to anthropogenic and natural sources. A major natural source is the oceanic emission of DMS (Dimethyl sulphide) which is oxidized to sulphuric acid via sulphur dioxide. Sulphur dioxide is also originated by anthropogenic combustion processes of fossil fuels. Sulphuric acid is a source for new aerosol particle formation. In a different process sulphuric acid does also build sulphate aerosol by agglomeration with existing particles. The relative efficiency of these processes depends on the availability of surface concentration of particulate matter. However, the major part of sulphate-containing aerosol observed at VRS has been identified to be of anthropogenic origin. During the haze event the particles usually interact with the existing water vapour leading to hygroscopic growth of existing sulphate-containing aerosols. The visibility is then highly reduced because of efficient scattering of the water-grown particles, an effect that also can strongly impact on the radiation budget and thus on Arctic temperatures. A picture of Arctic haze is presented in Figure 3.2.

NATURE PUBLICATION ON

OBSERVATION OF IODIC ACID NUCLEATION AT THE VILLUM RESEARCH STATION, STATION NORD IN NORTH GREENLAND

PARTICLE FORMATION IN THE ARCTIC ATMOSPHERE

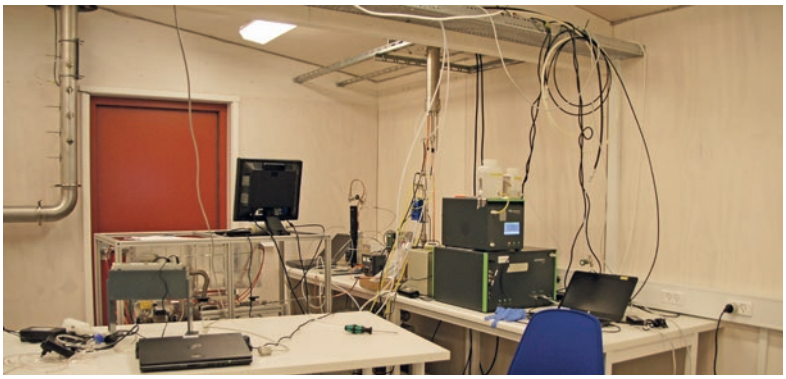
By Sipilä *et al.*

NUCLEATION SCIENCE

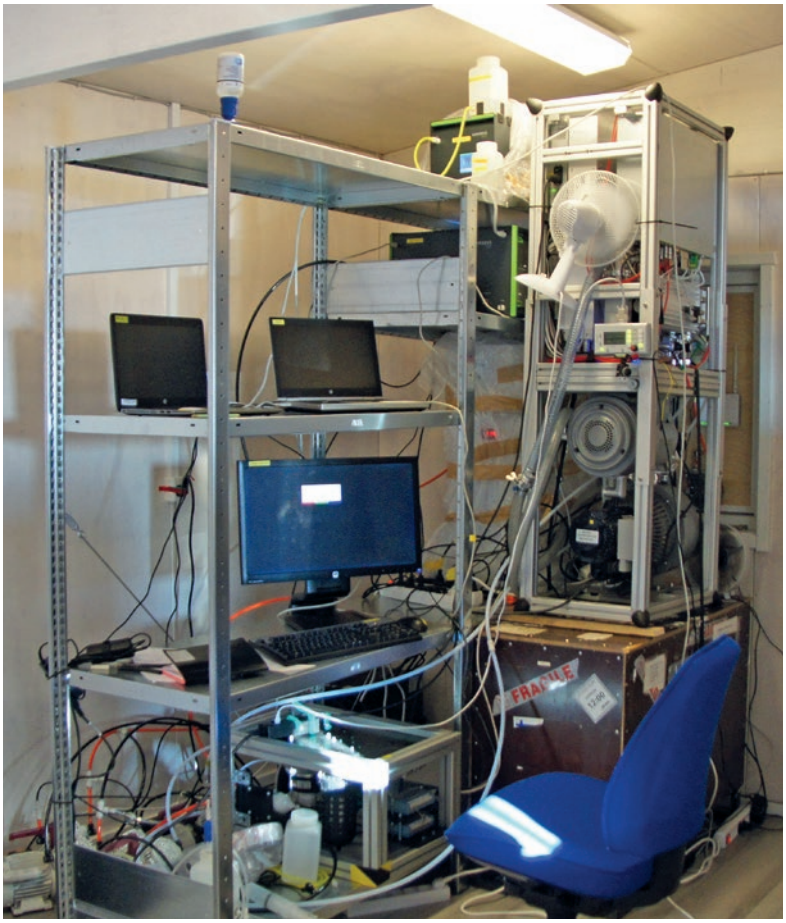
Introduction

Homogeneous nucleation and subsequent cluster growth is a major source of new aerosol particles and cloud condensation nuclei in the polar atmosphere. However, the detailed steps of cluster formation have not been elucidated in the Arctic or, even more widely, hardly in any atmospheric environment. Recently, the details of cluster formation process were resolved in a coastal environment on the west coast of Ireland, where it was found that iodine oxides, and especially iodic acid, HIO_3, are responsible for cluster formation and growth (Sipilä *et al.*, 2016). In the same publication, indications on the role of HIO_3 in the cluster formation at the Villum Research Station (VRS), Station Nord in the Northernmost Greenland were reported.

VRS is located on a peninsula surrounded most of the year by sea ice. Sea ice, or likely the phytoplankton inhabiting the sea ice, is a source of iodine vapours in the atmosphere (Atkinson *et al.*, 2012). Previous research has found particle formation in connection with iodine emissions over Weddell sea ice, Antarctica (Roscoe *et al.*, 2015). Iodine has been found also from larger, grown particles from the Arctic polar atmosphere (Allan *et al.*, 2015). These observations suggest that iodine could play a role in cluster and new particle formation at the VRS site.

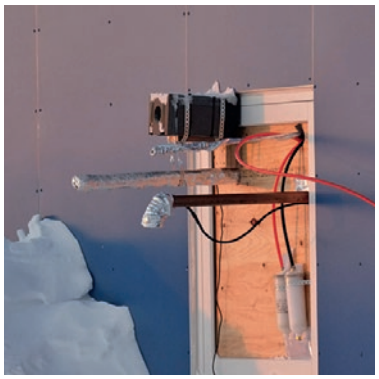


Particle Size Magnifier (PSM) Photo: Christel Christoffersen

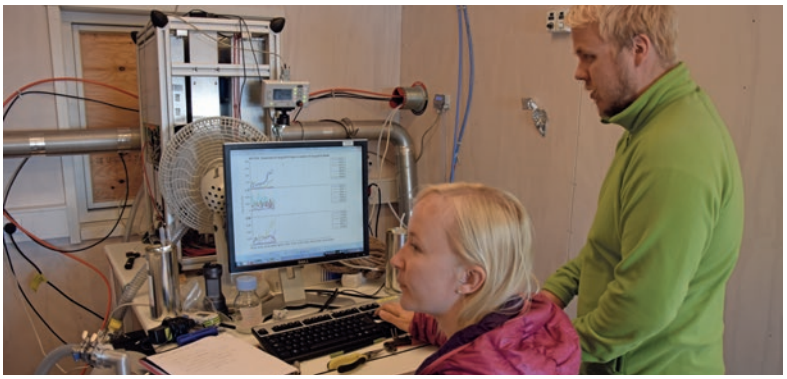


Chemical Ionization – Atmospheric Pressure Interface – Time-of-Flight mass spectrometer (CI-APi-TOF). Photo: Christel Christoffersen

Mikko Sipilä[1], Nina Sarnela[1], Heikki Junninen[1], Tuija Jokinen[1], Otso Peräkylä[1], Daniela Wimmer[1], Oskari Kausiala[1], Lauri Ahonen[1], Jyri Mikkilä[1], Markku Kulmala[1], Ingeborg Elbæk Nielsen[2], Andreas Massling[2], and Henrik Skov[2].
[1]Department of Physics, University of Helsinki, Finland.
[2]Arctic Research Centre; Department of Environmental Science, Aarhus University, Denmark



Inlets to mass spectrometers ran by Helsinki University. Photo: Heikki Junninen

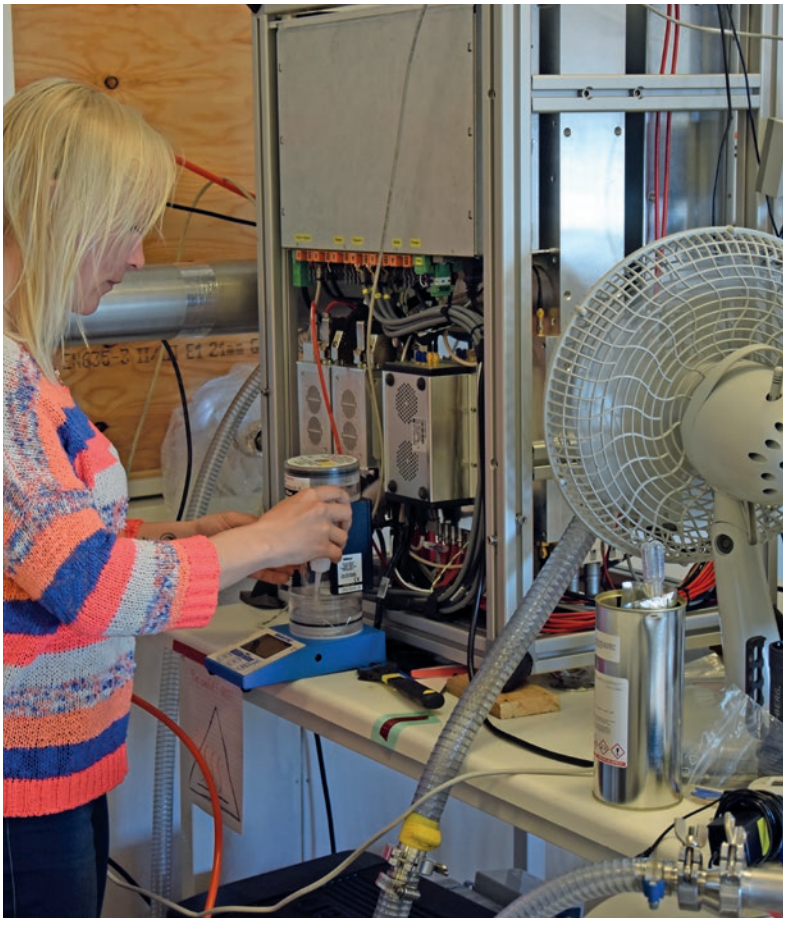


Methods

To resolve the cluster and new particle formation process a measurement campaign was conducted at the VRS site from February until the end of August, 2015. The key tool for resolving the cluster formation mechanism and the chemical compounds involved was a Chemical Ionization – Atmospheric Pressure Interface – Time-of-Flight mass spectrometer (CI-APi-TOF) that enables detection of clusters in the mass range from ~50 Da up to 2500 Da.

The instrument setup included also an APi-TOF mass spectrometer, that was used for detecting the naturally charged ion clusters, a Differential Mobility Particle Sizer (DMPS) for size distribution measurements between 10-800 nm, Neutral cluster and Air Ion Spectrometer (NAIS) for size distribution measurement of ions and neutral particles in the size range of 0.8-40 nm and 2-40 nm, respectively, and a Particle Size Magnifier (PSM) for size distribution measurements between 1.5 and 4 nm.

Researchers from Helsinki University at the Time-of-Flight mass spectrometer. Photos: Mikko Sipilä



Results

Several new particle formation events were recorded during the campaign. Peaks in event frequency occurred in the springtime, after the sunrise from late March until May, and in August. During the first event period, relatively high concentrations (over 10^7 molecules cm^{-3}) of HIO_3 were observed. However, during the summer, HIO_3 concentration diminished significantly possibly due to melting of the sea ice and subsequent decrease in emission of iodic acid precursors. While the new particle formation during the August events cannot be explained by iodic acid due to its low concentration (below 10^6 molecules cm^{-3}), iodic acid explains the cluster formation during the springtime. Figure 4.1 shows, in terms of a mass defect plot, a typical cluster distribution recorded by the CI-APi-TOF during events.

The pathway, we propose to explain the recorded cluster spectrum, is as follows:

Clusters or molecules we are able to detect with the CI-APi-TOF are shown with a bold font. Cluster growth continues via further sequential addition of iodic acid and recycling of water. It should be noted here, that intra-cluster restructuring reaction leading to I_2O_5 formation and water recycling may take place also inside the vacuum of the mass spectrometer. In that case the cluster composition in the atmosphere would be simply $(HIO_3)_n \cdot (H_2O)_m$.

Further studies around the polar areas are required in order to understand the formation pathways of iodic acid and relative importance of iodic acid, and iodine in general, in new particle formation in the arctic atmospheres. Also other mechanisms, such as those involving sulphuric acid, need to be resolved before atmospheric nucleation in the arctic environment can be declared comprehensively solved.

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Nature, 537, 532–534 (2016).

$$HIO_3 + HIO_3 \rightarrow HIO_3 \cdot HIO_3 \rightarrow I_2O_5 + H_2O$$

$$I_2O_5 + HIO_3 \rightarrow I_2O_5 \cdot HIO_3$$

$$I_2O_5 \cdot HIO_3 + HIO_3 \rightarrow I_2O_5 \cdot HIO_3 \cdot HIO_3 \rightarrow (I_2O_5)_2 + H_2O$$

$$(I_2O_5)_2 + HIO_3 \rightarrow (I_2O_5)_2 \cdot HIO_3 \,,...$$

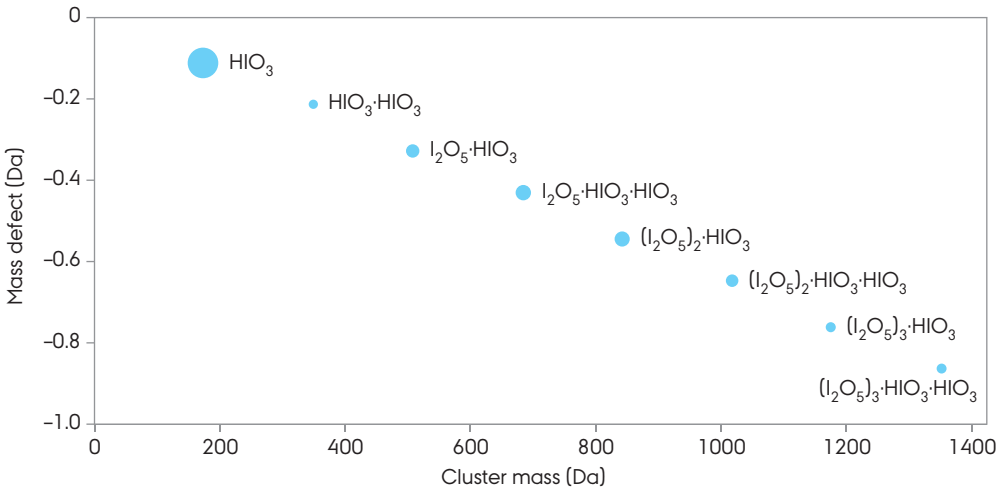


Figure 4.1.
Example mass spectrum recorded at Villum Research station, Station Nord in spring 2015. Mass defect describes the difference between the measured mass (in Da) and the sum of nucleons in the atomic nuclei of the clusters and, together with the cluster mass, unambiguously reveals the atomic composition of the clusters. Area of the dot is related to the observed signal strength. For clarity, only the iodic acid and iodine oxide clusters are depicted.

THE GREENLAND ICE SHEET'S RESPONSE TO PAST CLIMATE CHANGE

GEOLOGICAL RECORDS EXPAND OUR KNOWLEDGE ABOUT THE ICE SHEETS RESPONSE TO PAST CLIMATE CHANGE

By Laura B. Levy, Daniel Skov and Nicolaj K. Larsen; Department of Geoscience, Aarhus University

The Greenland Ice Sheet is responding rapidly to present-day climate change and its future remains uncertain. Outlet glaciers that drain the ice sheet have increased in velocity in the past decade in response to warming. Understanding how the ice sheet will respond to future climate change is imperative as it holds ~7.3 m of sea level rise within its ice. Forecasts of the ice sheet's contribution to sea level rise by the end of the century have large uncertainties- partly because our observations of the ice sheet's response to climate change are short and only exist for the past few decades. To improve the accuracy of models that forecast the ice sheet's response to future climate changes, we use geologic records to expand the record of the ice sheet's response to past climate changes. Determining how the ice responded to past climate change can be used as an analogue for future climate changes.

Our research focuses on determining how fast the Greenland Ice Sheet retreated from its maximum extent during the last ice age (~21,000 years ago) through to the present-day. We do this by tracking the past extents of the ice sheet through time using a dating method called "surface exposure dating". Surface exposure dating allows us to constrain the time when the ice retreated, leaving the land underneath the ice exposed. This method is based on the influx of high-energy particles from supernova that enter the Earth's atmosphere and bombard the surface of the Earth. This "cosmic radiation" is so strong that it creates spallation reactions in the surface of rocks, forming the isotope beryllium-10 (10Be) from the oxygen atoms in the quartz (SiO_2) minerals. The 10Be only begins to accumulate once the rock surface is exposed to the atmosphere, therefore making it an ideal way to determine the timing of when glaciers retreated from the landscape.

GEOLOGY AND CLIMATE

Sampling near the edge of the Greenland Ice Sheet. Postdoc Laura Levy takes notes on a boulder sample, while PhD student Daniel Skov uses a rock saw to cut the surface of a rock sample. Photo: Nicolaj Larsen

Our field team near the edge of 79 Glacier, the largest outlet glacier of the northeastern sector of the Greenland Ice Sheet. From left to right: Laura Levy (postdoc AU), Daniel Skov (PhD student, AU), Thomas Dalentoft (Air Greenland mechanic), Nicolaj Larsen (associate professor, AU), and Kåre Amund Berli (Air Greenland helicopter pilot). Photo: Nicolaj Larsen

In the field, we look for large boulders sitting on bedrock that have been deposited when the ice retreated. Once we find a boulder, we take notes on the surroundings, photograph the sample and take measurements on the sample. To collect samples, we use a rock saw to cut into the surface of the rock and then use a chisel and a hammer to unseat the sample. Once back at the lab, we crush the rock samples and isolate the quartz grains. Then we extract the beryllium from the quartz in our new cosmogenic laboratory at the Department of Geoscience. We then measure all of our samples at the accelerator mass spectrometer at the Department of Physics at Aarhus University.

In 2016, we spent 3 weeks in northeastern Greenland collecting rock samples while we used the Villum Research Station as our home base. Using a helicopter to get our field sites, we visited 27 locations and collected over 90 samples between Peary Land to the north and Danmarkshavn to the south, covering ~700 km. We were lucky with the weather this year too- most days were sunny with clear skies and 5-10°C – perfect weather for fieldwork and traveling by helicopter.

Since returning from northeastern Greenland in August, we have been busy processing samples in the lab and will have new data in early 2017. Using these data, we expect to be able to constrain the timing and rate of ice margin retreat in northeastern Greenland since the last ice age.

GROWTH, FUNCTION, AND DISTRIBUTION OF SHRUBS IN THE HIGH ARCTIC

UNDERSTANDING THE MAGNITUDE ARCTIC ECOSYSTEMS WILL CHANGE IN THE FUTURE

By Signe Normand and Urs A. Treier; Department of Bioscience, Aarhus University

How do arctic shrubs respond to climate change? Answering this question is essential for understanding how the function of Arctic ecosystems might change in the future. Arctic shrubs are expected to grow taller, faster, and expand locally, in response to recent climate change. These responses, have been observed at several Arctic sites, while data from other sites suggest no or negative trends. Local environmental variation, e.g., in moisture and topography, have been shown to explain some of the observed variation in shrub growth as a response to climate change. However, most of the research so far, has been conducted at relative low latitudes within the Arctic. This calls for additional investigations of the growth, function, and distribution of shrubs across climatic and local environmental gradients in the high Arctic.

TERRESTRIAL ECOLOGY

The aim of the 2016 field campaign was to collect the data needed to investigate the variation in growth, functional traits, and the distribution of plant species at several sites from Princess Ingeborg's Peninsula towards the Inland ice (Figure 6.1). Specifically, data were collected for: (i) a dendro-ecological investigation of local shrub recruitment and growth pulses across time, their correlation with climate change, as well as their potential variation across environmental gradients, (ii)

Figure 6.1.
Field sites. Left: The red line delineates the area for which worldview 3 imagery were obtained during the field campaign; July-August 2016. The red dots show the approximate location of field sites visited during the campaign.
Middle-Right: Comparison of the resolution obtained with worldview 3 and RGB-camera mounted on the fixed-winged drone.

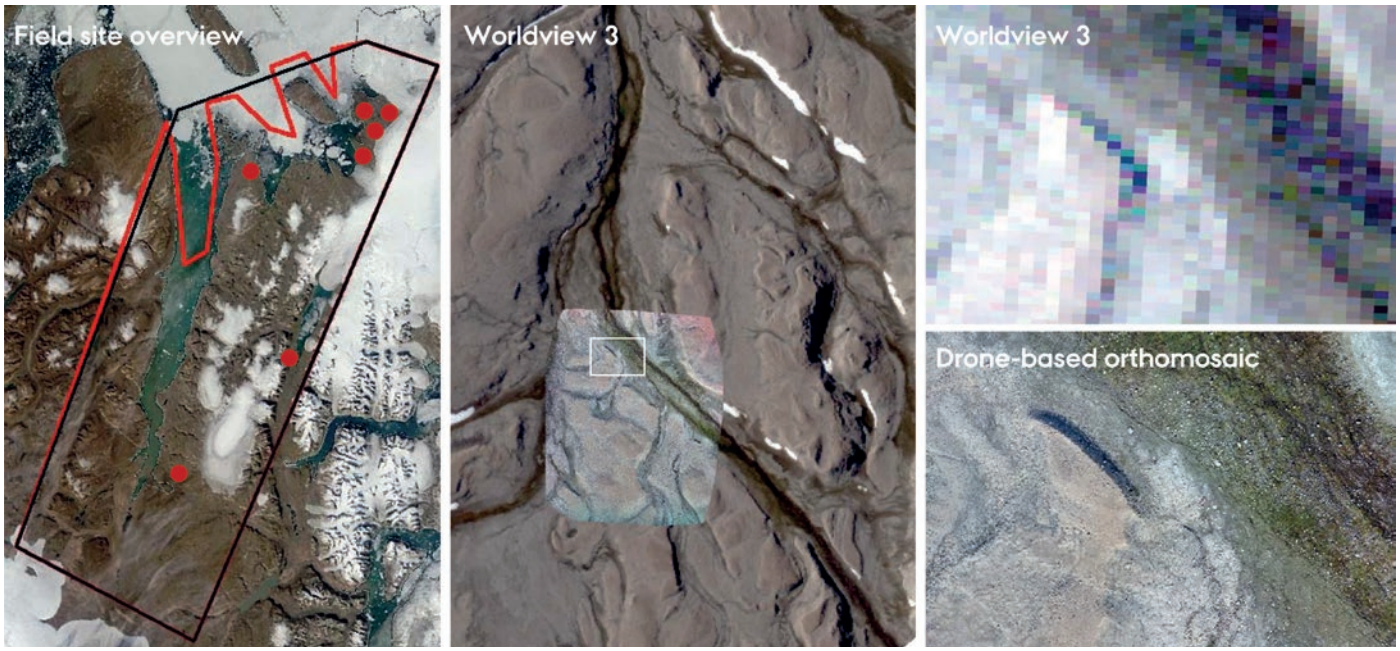


Figure 6.2.
Green veins with lush and moist Eriophorum dominated vegetation near the bottom of Danmarks Fjord. Here muskoxs grass both winter and summer.
Photo: Normand-Treier

Figure 6.3.
Impression from side valley near Romer Lake, here we camped and sampled during a week.
Photo: Normand-Treier

Figure 6.4.
Sampling *Salix arctica* for serial-sectioning at a site close to the ice cap at the south-western most part of Princess Ingeborg's Peninsula. Photo: Normand-Treier

mapping of the spatial distribution of the cover of shrubs and other vegetation types with ground-truthing in 2-m circles, ultra-high resolution imagery from drones (0.5-13cm, depending on the mounted sensor), high-resolution satellite imagery (worldview 3, <2m, Figure 1), and (iii) quantification of variation in species functional traits (especially specific leaf area, wood density, and vegetation heights) across climatic gradients. Data were collected in the green veins consisting of lush and moist Eriophorum dominated vegetation near the bottom of Danmarks Fjord (Figure 6.1, 6.2) and in a side valley near Romer Lake (Figure 6.1, 6.3), as well as in the otherwise mostly dry and stony areas with low vegetation cover dominating most of the region.

In total, wood and leaf samples were collected for several hundred individuals of four different shrub species. Ground-truthing was performed in 2-m circles by examining the floristic composition, by vegetation cover estimation from photography of a normal consumer-grade camera (RGB) and a near-infrared modified camera (NIR), as well as by collecting 1496 spectral samples with a handheld spectrometer covering different substrates and plant species (Figure 6.5). Drone images were acquired with a quadcopter drone (Micro-copter) and a fixed-winged (eBee RTK). The quadcopter was used at four of the sites flying with three different sensors (RGB, NIR and multispectral). The fixed-winged drone covered larger areas at the same sites but with lower resolution. The fixed-winged drone was equipped with three different sensors (RGB, multispectral and thermal). Lastly, high-resolution satellite imagery had been ordered to be obtained simultaneously with the field campaign; this data cover the whole research area and aims at assisting the upscaling of local findings to this high latitude region of north-east Greenland. The field campaign was successful and through laboratory and images analyses during the coming years, we expect to provide important insight on the growth, function, and distribution of shrubs across climatic and local environmental gradients in the high Arctic. Insight that will help us understand the magnitude by which Arctic ecosystems at high latitudes will change in the future.

Acknowledgement
We are very thankful to Bjarke Madsen, Lærke Stewart and Sigrid S. Nielsen for all their hard work and for making the field campaign of 2016 so successful and enjoyable.

Figure 6.5.
Sampling with hand-held spectrometer. Photo: Lærke Stewart

RADIO BROADCASTING FROM THE HIGH ARCTIC – VILLUM RESEARCH STATION – STATION NORD

THIS IS NOT THE END OF THE WORLD – BUT YOU CAN SEE IT FROM HERE

By Gitte Hansen

Barely had I landed on Station Nord before a Canadian pilot bandied about the first North Pole quote: This is not the end of the world – but you can see it from here. I felt the exact same after a two hours flight from Longyearbyen over the numerous ice formations in the clearest blue water below us.

On the plane was a bunch of researchers from Aarhus University (AU). They were on their way to perform research at the Villum Research Station (VRS) – each within their field. My job on this trip was to produce a series of radio features for Danish TV-network DR and articles for www.dr.dk.

As an employee of Danish Broadcasting Corporation (DR) East Jutland – one of nine DR regional radio stations – I was made aware of the existence of VRS through some news features on the radio. One of them being a feature about the Queen not being able to attend the inauguration of the research station. It was around this incident that I had the idea to make a news feature trip.

PERSONAL EXPERIENCE

It was an idea that I knew would be very difficult to realize, even if the radio station "P4 East Jutland" had a desire to communicate research from the local university (AU) to their radio listeners and even if environmental and climate research were relevant topics. Accordingly there was no lack of interest in establishing some sort of cooperation. However, such a trip is costly and thus not

Gitte Hansen at the Greenland Air helicopter. Photo: Laura Levy

The landmark of Station Nord. Photo: Jesper Kamp

Danish Broadcasting Corporation (DR) transmitted and presented on its homepage a number of programs (in Danish) from Villum Research Station and Station Nord during 2016.

Articles on dr.dk

http://www.dr.dk/nyheder/regionale/oestjylland/signe-er-biolog-hoejt-mod-nord-de-er-snu-de-smaa-vaekster
http://www.dr.dk/nyheder/webdok/stationnord
http://www.dr.dk/nyheder/viden/miljoe/danske-forskere-og-forsvaret-sikrer-polarforskning-taet-paa-nordpolen
http://www.dr.dk/nyheder/viden/miljoe/nordgroenlandske-sten-viser-hvornaar-indlandsisen-forsvinder
http://www.dr.dk/nyheder/viden/miljoe/velbekomme-isbjoerne-til-morgenmad-en-uddoed-dinosaur-og-700-milliarder-liter

Radio on P1:

http://www.dr.dk/p1/panorama/panorama-2016-10-06
http://www.dr.dk/p1/feature/feature-kulde-kaerlighed-og-kammeratskab
Plus indslag om samarbejdet mellem Station Nord og VRS

Radio on P4 East Jutland (7-16 November):

Indslag med Troels fra Siriuspatruljen
Om VRS – plus nyhed og Facebook
Jakob Vinther om fossilfund i Siriuspasset – plus Facebook
Om Plantebiologer – plus nyhed og Facebook
GEUS om is – plus nyhed og Facebook
Laura Levy om at forske i Danmark
Villy Dohrmann om at tilse DMI vejrstationer
Geologer om isens tilbagetrækning (Nicolaj, Daniel og Laura) – plus Facebook
Insektbiologer (Oskar og Tobias) – plus nyhed og Facebook
GEUS på jagt efter olie (og dinosaurer) (Morten og Jussi) – plus Facebook

an everyday occurrence for the P4 radio station. As it turned out, other DR departments were interested in feature stories and news items and that helped the financing of the trip. It was arranged that I could stay in one of the Defence Command Denmark's military buildings and that their Hercules aircraft would bring me back home again; this meant that my stay would be of convenient length.

After a long logistical puzzle, all the practical pieces fell into place – only for a new kind of puzzle to begin. I could not go there without ensuring some kind of activity at the VRS; I had to have researchers willing to talk to me about stories that would interest the radio listeners of P4 East Jutland.

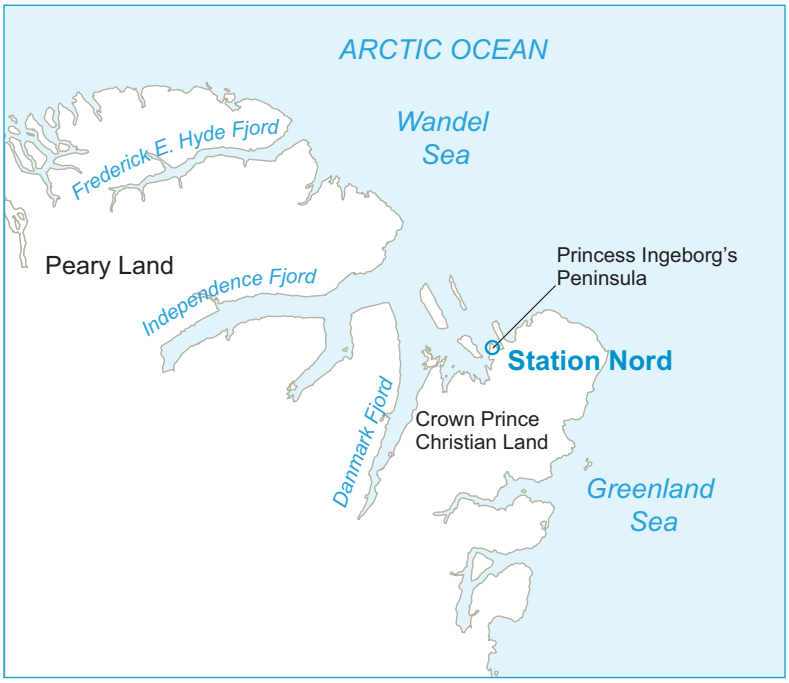
However, I was met with great kindness, goodwill and lenience, walking around with my microphone and camera asking for interviews, photographs and films. Even when I revealed that I did not know a *Purple Saxifrage* from an *Arctic Poppy*. They only laughed a bit when I wrongly termed *Ivory Gulls* as "snow gulls". And it was forgiven, that I did not quite know when the Cambrian Explosion actually took place.

And then, there was almost always coffee on the pot in the bright, modern living room of VRS.

The Canadian pilot had another quote: "When in Arctic leave nothing but footprints, take nothing but pictures".

I would like to add that in addition to the pictures, I have also taken a lot of incredible adventures and experiences with me from that week I spend 933 kilometres from the

Photo: Per Arne Bjeglerud.



FACTS ABOUT VILLUM RESEARCH STATION

By Station Coordinator Niels Bohse Hendriksen and Head of Station Henrik Skov

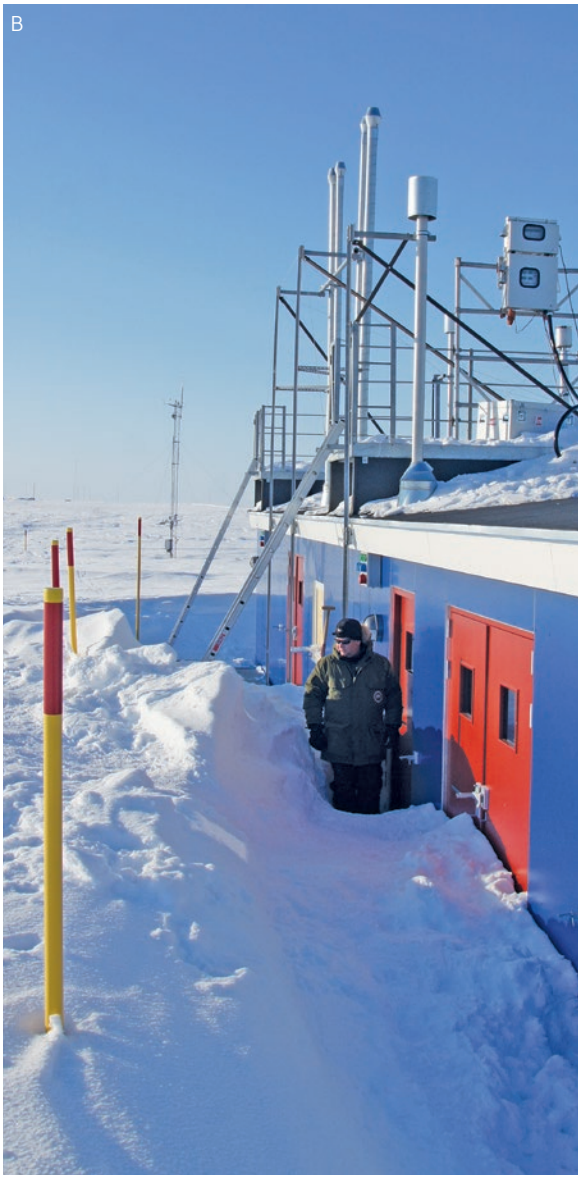
Villum Research Station – Station Nord is a new top modern research station established in 2014 and with inauguration in Summer 2015. It is a multidisciplinary research station that provides a unique research platform for climate and climate related research in high Arctic. As a unique feature it is open year round and thus it is possible to conduct research even during polar night. Villum Research Station is also a step-stone for field studies in north-eastern Greenland. It can host up to 14 scientists at a time. Your research projects are very welcome at the station. See our webpage for details: www.villumresearchstation.dk.

Villum Research Station is located at the military outpost Station Nord in high Arctic Greenland (81°36'11" N, 16°39'20" W). The station is a substantial upgrade of an existing air pollution monitoring hut (Flyger's hut). Villum Research Station is situated on the small peninsula Princess Ingeborg's Peninsula. The nearest town is Longyearbyen on Svalbard (Norway) 720 km east of the station, while the nearest town in Greenland is Ittoqqortoormiit, 1,250 km south of Station Nord. Station Nord is a gateway to the national park in North Greenland, and a support and refurbishment base for the Danish dog sledge patrol Sirius.

FACTS

Villum Research Station is owned by the Greenland Government and is being operated by Aarhus Uni-

Leaving the station. Photo: Christel Chrisoffersen



A. The dogs of the Sirius patrol. Photo: Heikki Junninen
B: Air Monitoring House in April seen from south – at the roof is inlets for gas and particle measurements seen. Photo: Christel Christoffersen
C. Dinner at the station. Photo: Henrik Skov
D. The mobile station in action. Photo: Henrik Skov

versity (Denmark) in cooperation with the Danish Defense (the Arctic Command). The station is based on means provided by the Danish private fund Villum Foundation.

The station hosts individual scientific projects focusing on atmospheric, marine, terrestrial, geological and biological research. In addition to this, the station is also used as a permanent base for an extensive long-term monitoring program, which traditionally had main focus on atmospheric pollution but has now increasing activities in Climate Change, Arctic marine and terrestrial ecosystems as well as geology.

It consists of a base station with accommodations facilities for researchers and modern laboratory facilities, a mobile station, which makes it possible to make field work at longer distances from the buildings, and an air station, which includes advanced equipment for aerial research and four drones.

PUBLICATIONS

RESEARCH PAPERS

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Zhang, H., Fu, X., Ramachandran, R., Cossa, D., Knoery, J., Marusczak, N., Nerentorp, M. and Norstrom, C. (2016).
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BOOK CHAPTER

Skov, H., Bossi, R., Massling, A., Sørensen, L.L., Nøjgaard, J.K., Christensen, J.H., Hansen, K.M., Jensen, B. and Glasius, M. (2016).
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CONFERENCE CONTRIBUTIONS & OUTREACH

CONFERENCE CONTRIBUTIONS

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VOC measurements at Villum Research Station (North Greenland) with PTR-TOF-MS.
Abstract to First year of research activities at Villum Research Station, Station Nord, North Greenland. Poster at the 2nd Pan-Eurasian Experiment (PEEX) Science Conference. Beijing, China, 18th-20th May 2016.

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Massling, A., Hendriksen, N.B., Nøjgaard, J.K., Bossi, R. and Skov, H. (2016).
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Leipziger Meteorologisches Kolloquium, 2nd June, Leipzig, Germany.

Massling, A., Christensen, J., Hendriksen, N.B., Nøjgaard, J.K., Bossi, R., Nielsen, I.E., Svendsen, S.B., Skov, H., Jensen, B., Christofferson, C. and Skafte, J. (2016).
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Massling, A., Hendriksen, N.B., Nøjgaard, J.K., Bossi, R., Skov, H., Jensen, B., Christofferson, C. and Skafte, J. (2016).
Villum Research Station (VRS) – a short introduction on science activities.
PAMARCMIP 2018 campaign planning meeting, 18th–19th October, University of Bremen, Bremen, Germany.

Šantl-Temkiv, T., Starnawski, P., Gosewinkel, U., Rauter, U., Pilgaard, P., Alsved, M., Marshall, Tesson, I.S., Lever, M., Löndahl, J., Lange, R., Gunde-Cimerman, N., Svendsen, S., Massling, A. and Finster, K. (2016).
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Skov, H., Bossi, R., Massling, A., Nøjgaard, J.K., Nielsen, I.E., Nguyen, Q.T., Vorkamp, K., Lange, R., Poulsen, M.B., Christensen, J.H., Hansen, K.M., Bilde, M., Glasius, M., Sørensen, S.B., Šantl-Temkiv, T., Finster, K., Pilgaard, S., Sørensen, L.-L., Jensen, J.K. and Liisberg, J.B. (2016).
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Invited speaker at Polarforskningskonferencen 1st-2nd November.

Skov, H., Massling, A., Nøjgaard, J.K., Hendriksen, N.B., Christoffersen, C., Bossi, R., Jensen, B., Sørensen, L.-L. and Skafte, J. (2016).
Research Opportunities at Villum Research Station, Station Nord.
Invited speaker at Unis 26th September.

Skov, H., Bossi, R., Massling, A., Nøjgaard, J.K., Nielsen, I.E., Nguyen, Q., Vorkamp, K., Lange, R., Christensen, J.H., Hansen, K.M., Bilde, M., Glasius, M., Sørensen, L., Jensen, J.K. and Liisberg, J.B. (2016).
Air pollutants and climate studies at Villum Research Station.
Invited speaker 26th September.

Svendsen, S.B., Lange, R., Skov, H., Christensen, J.H., Nøjgaard, J.K., Nguyen, Q.T., Glasius, M., Hansen, A.-M.K., Iversen, L.S. and Massling, A. (2016).
Submicrometer aerosol chemical composition at a high Arctic site: a comparison of experimentally derived and modelled results.
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OUTREACH

Lange, R. and Massling, A. (2016).
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Dansk Kemi, 97 (8), 10-12.

Villum Research Station – Station Nord – 2015 Annual Report.

MEMBERS OF BOARDS

STEERING BOAARD

Name	Title	Affiliation
Niels Christian Nielsen (Chair)	Dean, Professor	Aarhus University
Lars Hansen	Director	Villum Foundation
Thomas Sinkjær	Research Director, Professor	Villum Foundation
Mikael Kristensen	Director	Government of Greenland
Jens Heine Grauen Larsen	Commander	Defence Command Denmark
Marit-Solveig Seidenkrantz	Professor	Aarhus University
Carsten Suhr Jacobsen	Head of Department, Professor	Aarhus University
Henrik Skov	Scientific Head of Station, Professor	Aarhus University

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All members are affiliated to Department of Environmental Science, Aarhus University.

Name	Title
Henrik Skov	Scientific Head of Station, Professor
Jørgen Skafte	Logistics Coordinator
Andreas Massling	Responsible for physical measurement, Dr.
Rosanna Bossi	Responsible for chemical measurements, Dr.
Jacob Klenø Nøjgaard	Responsible for determination of organics in aerosols, Dr.
Lise Lotte Sørensen	Responsible for Integrated Carbon Observation System, Dr.
Niels Bohse Hendriksen	Station Coordinator, Dr.
Bjarne Jensen	Affiliated technician
Christel Christoffersen	Affiliated technician

SCIENCE COORDINATION BOARD

Name	Title	Affiliation
Henrik Skov (Chair)	Scientific Head of Station	Department of Environmental Science, Aarhus University (AU)
Søren Rysgaard	Head of Arctic Research Center (AU)	Deparment of Bioscience, AU
Signe Bech Andersen	Senior Scientist	Geological Survey of Denmark and Greenland (GEUS)
Niels Kroer	Head of Department	Department of Biology, University of Copenhagen (KU)
Nicolai Krog Larsen	Associated professor	Department of Geoscience, AU
Mathew S. Johnson	Professor	Department of Chemistry, KU
Bo Elberling	Professor	Department of Geoscience and Resource Management, KU
Rene Forsberg	Head of Department	National Space Institute, Danish Technical University – Space
Niels Larsen	Head of Centre	Centre for Atmospheric Physics and Observations, Danish Meteorological Institute
Mikala Klint	Coordinator	Chemicals and the Arctic, Danish Environmental Protection Agency
Niels Martin Schmidt	Head of Zackenberg Research Station	Department of Bioscience, AU
Dorthe Dahl-Jensen	Professor	Centre for Ice and Climate, Niels Bohr Institute, KU
Bjarne Grønnow	Museum Director	National Museum of Denmark
John Mortensen	Senior Scientist	Greenland Institute of Natural Resources
John F. Burkhardt	Associate Professor	Department of Geoscience, University of Oslo
Margareta Johansson	Researcher	Department of Physical Geography and Ecosystem Science, Lunds University
Feiyeu Wang	Professor	Department of Environment and Geography, University of Manitoba
Anna Jones	Deputy Science Leader	Atmosphere, Ice and Climate Team, British Antarctic Survey
Angelika Humbert	Professor	Alfred Wegener Institute, Helmholtz Centrum für Polar und Meeresforschnung
Lise Lotte Sørensen	Senior Researcher	Department of Bioscience, AU
Niels Bohse Hendriksen	Station Coordinator	Department of Environmental Science, AU

PROJECTS & GENERAL SCIENTIFIC EQUIPMENT

PROJECTS

Long-range transport of particle pollution to the Arctic and physical properties of Arctic aerosols	Andreas Massling/Merete Bilde/ Marianne Glasius; Aarhus University
Greenhouse gas exchange over the Arctic Marine waters – focusing on CO_2 and CH_4 (GRAM)	Lise Lotte Sørensen/Tim Papakyriakou; Aarhus University
Microbial atmospheric-terrestrial coupling driven by long distance transport and deposition	Kai Finster; Aarhus University
Glacier melting rates, sea ice variability and ocean circulation in the Danmarks Fjord area, Northeast Greenland	Marit-Solveig Seidenkrantz/ Niels Nørgaard/Sofia Ribeiro; Aarhus University
Climate and lake ecosystem dynamics, in the high Arctic, over the Holocene, using lake sediment records	Nicolai Krog Larsen/ Torben Linding Lauridsen; Aarhus University
Determination of the photosynthetic responses and acclimation of sea ice algae to changes in light climate, especially as governed by snow thickness	Lars Chresten Lund-Hansen/Brian Sorrell; Aarhus University
Impact of snow cover on the inorganic carbon dynamic within sea ice	Nicolas-Xavier Geilfus; University of Manitoba
Sea ice geophysics – deployment of mass balance buoys	David Barber/David Babb; University of Manitoba
Sea ice geochemistry: mercury, ikaite, phosphate	Fei Wang/Søren Rysgaard/David Barber/ Yubin Hu; Aarhus University, University of Manitoba
Quantification of Ikaite	Søren Rysgaard/H. Kyle; Aarhus University
Comparison of the productivity and photosynthetic properties of microalgae in first-year and multi-year sea ice	Søren Rysgaard/Virginie Galindo; Aarhus University; University of Manitoba
Primary and bacterial productivity around St. Nord and near the ice tongue: impact of glacier melt	Søren Rysgaard/Virginie Galindo; Aarhus University; University of Manitoba
Sediment distributions and characteristics in seawater, sea ice and glacier ice	Jens Ehn; University of Manitoba
AUV measurements	Søren Rysgaard; Aarhus University
Near-shore dynamics, circulation and hydrography around St. Nord and the nearby ice tongue	Søren Rysgaard; Aarhus University

Impact of ocean heat on landfast ice and tidewater glaciers	Igor Dmitrenko/Sergei Kirillov; University of Manitoba
Mooring RETRIEVEment and redeployment	Igor Dmitrenko/Søren Rysgaard; University of Manitoba; Aarhus University
Drone- and functional ecological investigations of Tundra change	Signe Normand; Aarhus University
Arthropod communities along climatic gradients	Toke T. Høye; Aarhus University
The cloud forming potential of atmospheric particles	Andreas Massling; Aarhus University
The dynamics of mercury in the Arctic atmosphere	Henrik Skov; Aarhus University
Mooring retrievements	Igor Dmitrenko; University of Manitoba
Danish contribution to Arctic monitoring and assessment program (AMAP)	Henrik Skov; Aarhus University
Meteorological and pollutant observations in the high Arctic	Andreas Massling; Aarhus University
KOPRI	Sangjong Park; Korea Polar Research Institute
INHALE experiment Grenoble	Aurelién Dominique; Grenoble University
Integrated Carbon Observation System (ICOS)	Lise-Lotte Sørensen; Aarhus University
Climate forcers in the high Arctic	Markku Kulmula; Helsinki University
Marine waste – occurence and composition of marine waste in Greenland	Jakob Strand; Aarhus University

GENERAL SCIENTIFIC EQUIPMENT

Find details on equipment available at our webpage

Chemistry	Filter Pack Sampler (Inorganics: Elements (ICP-MS), SO_4^{2-}, NO_3^-, NH_4^+ (IC)) High Volume Sampler (Carbonaceous: EC/OC (Thermo-optical method and Identification of organo sulfates)) High Volume Sampler (POPs) Chemical speciation of aerosols using a SP-TOF-MS
Particle physics	Particle number size distribution (10 - 900nm, SMPS) Particle number size distribution (0.5 - 32µm, OPC) Chemical composition of particles (AMS) Absorption coefficient / Black carbon mass concentration (MAAP) Scattering coefficient at three wavelengths (Nephelometer) Speciation of gas phase compounds using a PTR-TOF-MS
Laboratory equipment	Basic chemistry and microbiological equipment UV spectrometer Fuming cupboards Flow bench - 80 °C freezer Deionisation system
Marine equipment	Two rubber boats Ice drills Plankton nets Van Veen grap CTD pCO_2 instrument
Terrestrial equipment	Vehicles for transport of equipment Snow mobiles Tents for different purposes
The air station	Drones for different purposes

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