UNIS
The University Centre in Svalbard

ANNUAL REPORT 2019

Front page | **August 2019:** AB-201/204 students count Silene flowers in Woodfjorden. Photo: Mads Forchhammer/UNIS.

Editor | Eva Therese Jenssen.

October 2019: Longyearbyen seen from Sukkertoppen.
Photo: Emil Söderlund/UNIS.

FROM THE DIRECTOR

UNIS exploits the advantages that our favourable location offers, making it possible for the universities on the Norwegian mainland and our partners to have easier access to the Arctic for their research and education. With 213 student-labour years in 2019 divided among 743 students from 43 countries, UNIS makes a significant contribution to recruiting, motivating and training the next generation of polar scientists.

For Norwegian students, a period of study at UNIS is easily accessible and, I would say, a convincing alternative to a period of study abroad. In addition to offering an international, extremely social, safe and good student environment, we offer international teaching through an extensive guest lecturer programme. Students at UNIS develop contact networks that expand their horizons for future careers.

Fieldwork in the surrounding areas is at the core of UNIS' educational provision, and the major resources we can use on students in the field and on research cruises is what distinguishes us from other higher education institutions. Svalbard has a favourable location for global climate and environmental studies. The students live close to the forces of nature and are given opportunities to observe and research the impacts of global pollution and climate change. Scientific knowledge is put to practical use to handle natural hazards and one's own safety. Thorough safety training on arrival enables our students to practice safe and secure behaviour and, in so doing, develop skills that are sought-after by future employers.

We prioritise using our resources on quality education and research and, as the annual report shows, we succeed with this.

SAMCoT – Sustainable Arctic Marine and Coastal Technology – was discontinued in 2019. SAMCoT was a Centre for Research-based Innovation. UNIS was a partner in SAMCoT right from its inception in 2011 when the ambition was to be an international leader in the development of robust technologies used by the industry operating in the Arctic. The goal of SAMCoT was to perform research that would help the industry achieve environmentally friendly development of the Arctic where ice, frozen soil/permafrost and coastal erosion represent unique challenges.

By pursuing this goal and achieving success, SAMCoT played a role in making the host institution, the Norwegian University of Science and Technology (NTNU) and its key research partners, UNIS and SINTEF, a leading international centre for Arctic science and technology. The consortium consisted of 9 research partners, 12 industrial partners and 2 public partners. The Department of Arctic Technology the Technical and Logistics Unit at UNIS have played a key role in this development. We will continue to develop this competence in the future.

Jøran Moen is managing director of UNIS.
Photo: Eva Therese Jenssen/UNIS.

We are still a partner in a Norwegian Centre of Excellence in space physics research and a Centre of excellence in biology education, and in 2020 we will be a partner of another Centre of excellence in geoscience education. In addition, we have a stable portfolio of major and minor research projects and in 2019 had 161 articles published in peer reviewed journals.

Norway ranks third in the Arctic behind the United States and Canada when it comes to research. Outstanding research, research training and the recruitment of young research talents is important for Norway to further strengthen its position in international polar research. Furthermore, we must position our research infrastructure so that it is part of an international Earth observation system. UNIS is partner in the *Svalbard Integrated Arctic Earth Observing System (SIOS)*. SIOS aims to coordinate all Earth observations in Svalbard, so that we can succeed in Svalbard becoming an integrated part of a global Earth observation system.

On 3 October 2019, the government presented its *strategy for innovation and economic development in Svalbard.* This strategy provides major development opportunities for UNIS and our partners. The government provides clear signals that it will prioritise knowledge-based industry in Svalbard, and it shows a willingness to act. UNIS gained two additional PhD positions earmarked energy, which poses a significant challenge from a sustainability perspective. We also received support to further develop the Arctic Safety Centre, which will contribute to increasing the competence in safe human activity in the Arctic, with special emphasis on developing the centre's relevance and provision for the industry. Development of innovation and societal relevance are in line with UNIS' Strategy 2025 and will be key in the further development of the institution.

Jøran Moen
Managing director

EXCERPT FROM THE
BOARD OF DIRECTORS' REPORT 2019

May 2019: The Minister of Research and Higher Education, Ms. Iselin Nybø, visited UNIS and the Kjell Henriksen Observatory (KHO). Here pictured in one of the KHO domes. Photo: Mikko Syrjäsuo/UNIS.

The University Centre in Svalbard AS (UNIS) is a state-owned limited corporation, owned and administered by the Norwegian Ministry of Education and Research. The enterprise's objective is to provide an educational provision and engage in research based on Svalbard's geographic location in the High Arctic and the special advantages this offers, by using the nature as a laboratory and arena for observations and collection and analysis of data. The educational provision shall be at university level and act as a supplement to the tuition offered at the universities on the mainland and form part of an ordinary programme of study leading to examinations at bachelor's, master's and PhD level.

The educational provision shall have an international profile, and all tuition shall be given in English. There shall be a balance between Norwegian and international students. Through its activities, the enterprise shall contribute to community development in Longyearbyen and Svalbard in line with the overarching objectives of Norwegian Svalbard policy.

EDUCATION AND STUDENT STATISTICS

UNIS' commission from the Ministry of Education and Research for 2019 was to develop an educational provision that represents approximately 220 student-labour years.

In 2019, 743 students spent shorter or longer periods at UNIS, including both course students and guest master's students. In addition, one guest bachelor's student and 12 guest PhD students were registered at the institution.

Of the students in 2019, 50% came from programmes of study at Norwegian universities, while the proportion of Norwegian citizens was 32%. The discrepancy between Norwegian citizens and students from Norwegian universities may be attributed to the fact that foreign nationals are admitted to ordinary programmes of study at Norwegian universities. In recent years, UNIS has had a reasonably balanced gender distribution, with a slight predominance of women. The proportion of women has increased in recent years and in 2019 57% of the students were women. UiT – The Arctic University of Norway is the Norwegian university that sends the most students to UNIS, closely followed by the Norwegian University of Science and Technology (NTNU).

A total of 213 student-labour years were produced at UNIS in 2019 (down from 218 in 2018), of which 193 student-labour years were linked to credits (ECTS) from completed courses and 20 student-labour years linked to presence by guest master's students. The decrease was primarily among bachelor's degree courses, as production at master's and PhD level has increase somewhat.

February 2019: UNIS and the Svalbard Science Centre in pink light, indicating the end of the dark season. Photo: Mads Forchhammer/UNIS.

The Department of Arctic Geology experienced the largest decrease in terms of both production and course provision, but still has the highest production and largest educational provision at UNIS. The Department of Arctic Geophysics has a reasonably stable educational provision, but has experienced a decline in production, which may be attributed to the low percentage of places filled on some of the courses. Courses in Arctic Safety are reported for the first time as a separate group and now constitute 9% of the total production at UNIS.

In line with previous years, the results from the final assessment of the courses has been above average, with B as the average grade. The failure percentage has been low (1%).

UNIS had 28 PhD candidates (both internal and external) in 2019, and four public defences were held.

RESEARCH AND ACADEMIC INITIATIVES – EXTERNAL FUNDING

In line with UNIS' new strategy, the institution is developing goals and organisational structures to strengthen research. In 2019, UNIS aimed at larger and more long-term projects in strategically important areas. This means a more pan-Arctic approach to research issues, while at the same time clarifying UNIS' corporate social responsibility in Longyearbyen. This requires a clearer and strategic research leadership at UNIS combined with a strengthening of the institution's research administrative apparatus. In 2019, the Dean of Research and the institution's Research Committee developed several policies concerning handling of application processes, the use of PhD as strategic measures and a plan for publishing. These have now been sent out for comment within the organisation and will form the basis for the development of a set of rules for research that has now commenced. This is part of the *Compliance* project at UNIS, and the rules for research are intended to safeguard the processes and legal basis for external project funding, including delegation rules, the TDI full cost model for research infrastructure and contract rules.

UNIS has increased its project portfolio during 2019 and received funding for several major new projects. In 2019, the Department of Arctic Biology (AB) was successful with a major research application (FACE-IT) to the EU's Horizon 2020, along with Norwegian and international partners. The project is pan-Arctic and AB has a key role in the marine sampling in Svalbard. Furthermore, the Department of Arctic Geology (AG) and Arctic Geophysics (AGF) gained funding for a Centre for Excellence in Education (*iEarth*), which also has a significant research component. AG is leading a project funded by the Research Council of Norway about microorganisms in the ice (BIOICE), and a project about methane under the permafrost (CLIMAGAS).

In addition to the new projects, *the Nansen Legacy* involves research within marine biology and oceanography and is still the largest project at UNIS. The *Birkeland Centre for Space Science*, which is a Norwegian Centre of Excellence, still has significant activity, although it now has a reduced budget compared with previous years.

SAMCoT – Sustainable Arctic Marine and Coastal Technology – was a Centre for Research-based Innovation led by NTNU, which had 23 partners and was discontinued in 2019. The Department of Arctic Technology (AT) and the Technical and Logistics Unit at UNIS contributed to SAMCoT becoming a centre that was an international leader in the development of robust technologies that are used by the industry operating in the Arctic.

*Svalbard Integrated Arctic Earth Observing System (*SIOS) is organised as a subsidiary of UNIS. Its main task is to coordinate and develop further an international research infrastructure to research the regional effects of climate change.

In 2019, UNIS had a total of 150 large and small projects, which constituted a turnover from external activities of NOK 42,3 million.

DISSEMINATION AND VISITS

Around 1,100 people from Norway and overseas visited UNIS in 2019. The visiting delegations included several Norwegian parliamentary standing committees, as well as the Ministers of Research and Higher Education, Justice and Public Security, Local Government and Modernisation, and Agriculture and Food.

The American Ambassador to Norway along with a delegation from the US Congress, the Chinese Vice Minister of Science and Technology and a delegation from Greenland all used the opportunity to visit UNIS while they were in Svalbard.

In terms of media, it is mostly international companies that visit UNIS. In 2019, this included Sky News, Radio Television Suisse and Der Spiegel from Germany.

In January, UNIS organised the annual Svalbard Seminars in collaboration with the Norwegian Polar Institute and the Governor of Svalbard. The Outreach cruise, Svalbardkurset and Studietur Nord were all arranged in the summer and received positive feedback.

STAFF

Harald Ellingsen resigned as director effective 31 December 2019. Jøran Moen was appointed new director at the board meeting on 25 November 2019.

As of 31 December 2019, the academic staff at UNIS comprised of 13 professors, 13 associate professors, two researchers, six post docs, 17 internal PhD candidates and 40 staff with adjunct professor/associate professor attachments. The technical and administrative staff comprised 38 full-time equivalent work years.

Women accounted for 49% of the technical and administrative positions, 54% of the academic positions and 57% of the students. Five of the 11 members of the Board of Directors were women. The Board of Directors is not aware of discrimination of any form at UNIS. At year-end, the proportion of Norwegian citizens in permanent positions at UNIS was 57%.

The *Compliance* project, which aims to clarify the rights of the employer and employees, has made good progress in 2019. The regulations concerning appointments, leave

February 2019: The Lunckefjell mine entrance on Marthabreen nearby Svea. UNIS geologists lead a project to obtain high resolution paleoclimatic records from coal. During 2019 unique samples were collected from the Lunckefjellet and Svea Nord mines before closing. Photo: Rolf Stange.

of absence and housing were finalised in 2019, while the regulations concerning employment conditions and research will be finalised in 2020.

HEALTH, SAFETY AND ENVIRONMENT (HSE)

Absence due to illness at UNIS in 2019 was 1.5%. In late 2019, UNIS implemented a working environment survey, which shows that for the most part the working environment at UNIS is perceived as good. Work on follow-up measures will take place in 2020.

HSE has high priority, and the safety of our students, staff and visitors is an overarching consideration for the implementation of all activities at UNIS. We have special focus on the safe implementation of fieldwork and cruise activities in Arctic areas. In 2019, 85 field safety courses of various duration were held for 1,260 people.

UNIS' location in the High Arctic, characterized by unpredictable effects of climate change, provides special challenges in the entire HSE spectrum. It is important to take a proactive approach in our responsibility for safe and careful travel by our students and staff in the Svalbard nature. Quality assurance of the planning and implementation of field-based projects is implemented in a structured manner with strict requirements for work procedures and methods. Work at UNIS' laboratories is subject to the same quality assurance as work in the field.

UNIS cooperates closely with the local administration at the Governor of Svalbard and the Longyearbyen Community Council to find good solutions, particularly in connection with UNIS' activity in the field. In 2019, UNIS further developed the collaboration concerning the collection of the snow data used to prepare local avalanche forecasts for Longyeardalen and Nordenskiöldland.

UNIS' internal regulations are based on the formulation of objectives from the Svalbard Environmental Protection Act, which states that in the event of conflict between the activity and the environment priority must be given to environmental considerations.

UNIS is unaware of contamination of the wider environment to any significant degree due to the company's operations. UNIS works continually to limit the environmental impact of its activities.

ECONOMY

Funds for operation and investments at UNIS are appropriated in the budget of the Ministry of Education and Research. In 2019, the appropriations from the Ministry totalled NOK 136,187,000. In addition, an additional appropriation of NOK 6 million from 2018 was not registered as income until 2019. Of the total allocation registered as income, NOK 10,574,657 was used as investments in equipment.

Income over and above the appropriations from the Ministry of NOK 59,253,619 comprises NOK 42,257,596 in external project income for research and NOK 16,996,023 in income from rentals and other income.

The accounts for 2019 show an operating surplus of NOK 11,427,893. The background for the surplus is that we have had some vacant positions for parts of 2019, resulting in reduced salary and personnel costs. At year-end, all adopted recruitment processes are implemented and partially completed. In addition, external net income has increased significantly from previous years.

It is proposed that this surplus be transferred in full to shareholder equity, which strengthens UNIS' position for future strategic investments. See detailed info on pages 10 – 11.

BOARD OF DIRECTORS AND ANNUAL GENERAL MEETING

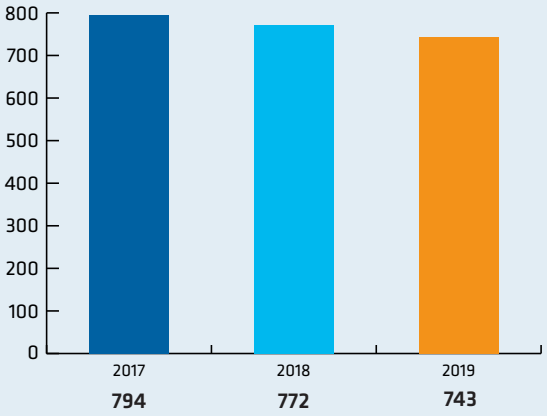
The Board of Directors held six meetings in 2019, including one meeting in Longyearbyen. A total of 66 items were officially discussed. The Annual General Meeting was held in Oslo on 20 June 2019.

17 MARCH 2020:

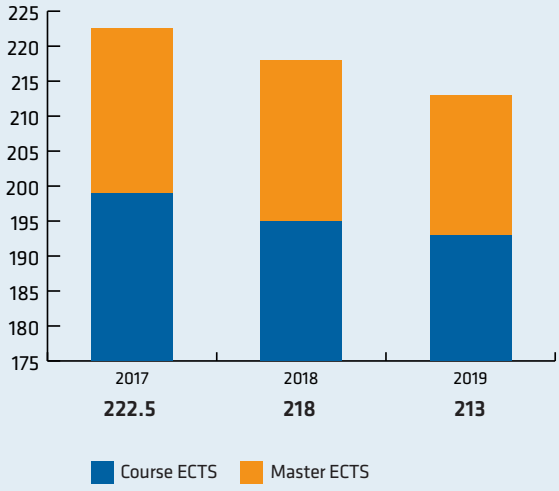
Chair Morten Hald (The Arctic University of Norway); deputy chair Nina Frisak; board members Robert Bjerknes (University of Bergen); Kristin Vinje (University of Oslo); Øyvind Weiby Gregersen (NTNU); Siri Kalvig; Arild Olsen (Longyearbyen Community Council); Pernille Bronken Eidesen, Petter W. Sele and Eli Anne Ersdal (staff representatives); Lidia Luque (student representative) and Jøran Moen (director).

STATISTICS

TOTAL NUMBERS OF STUDENTS

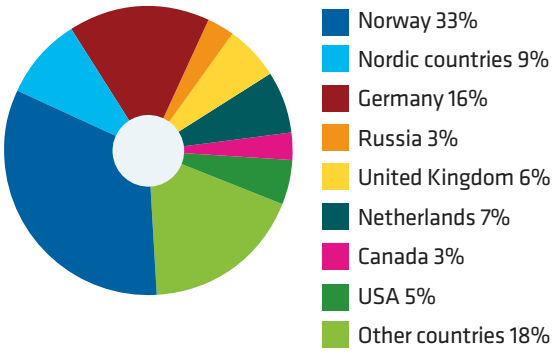


PRODUCTION IN STUDENT-LABOUR YEARS (1 YEAR = 60 ECTS CREDITS)

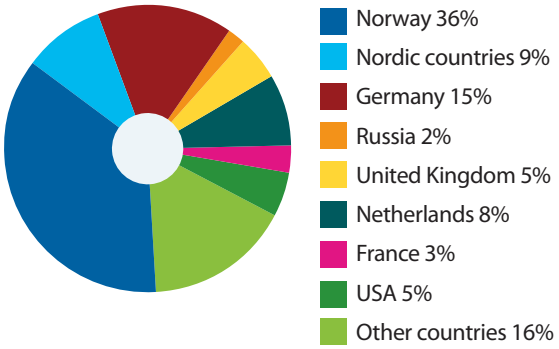


Note: UNIS registers ECTS by 1) course production and 2) master students attendance

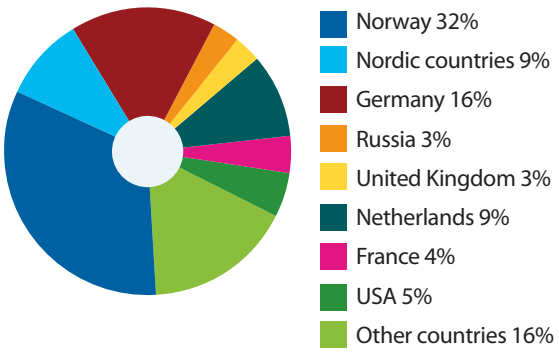
STUDENT NATIONALITY 2017



STUDENT NATIONALITY 2018



STUDENT NATIONALITY 2019



PROFIT AND LOSS ACCOUNT 2019

GROUP*			University Centre in Svalbard AS	
2019	2018		2019	2018
NOK	**NOK**	**OPERATING INCOME**	**NOK**	**NOK**
136 187 000	132 349 000	Operating grant from the Ministry	136 187 000	132 349 000
18 550 111	2 743 533	Other grants	6 000 000	-
-10 574 657	-6 269 242	Appropriation for investments	-10 574 657	-6 269 242
144 162 454	**128 823 291**	**Operating grant from the Ministry**	**131 612 343**	**126 079 758**
78 311 064	48 304 497	External project income	42 257 596	42 753 470
14 196 023	21 595 517	Other incomes	16 996 023	17 155 770
236 669 541	**198 723 305**	**Gross operating income**	**190 865 962**	**185 988 998**
70 791 691	48 304 497	Direct project expenses	34 738 223	37 269 836
165 877 850	**150 418 808**	**Net operating income**	**156 127 739**	**148 719 162**
		OPERATING EXPENSES		
79 274 862	77 776 277	Salary and related expenses	73 923 948	76 360 834
10 642 336	9 990 686	Fieldwork and cruise	10 642 336	9 990 686
36 679 589	35 738 835	Buildings	36 679 589	35 738 835
26 584 400	20 966 281	Other operating expenses	22 156 987	20 669 354
1 813 000	1 800 000	Depreciation	1 813 000	1 800 000
154 994 187	**146 272 079**	**Sum operating expenses**	**145 215 860**	**144 559 709**
10 883 663	**4 146 729**	**OPERATING SURPLUS**	**10 911 879**	**4 159 453**
		FINANCIAL INCOME AND EXPENSES		
1 220 889	878 187	Financial income	1 191 546	876 246
695 832	622 439	Financial expenses	675 532	621 060
525 057	**255 748**	**Net financial items**	**516 013**	**255 186**
11 408 720	**4 402 477**	**Net profit for the year**	**11 427 893**	**4 414 639**
		Information about appropriations to:		
		Transferred from/to other equity	11 427 893	4 414 639
		Sum transfers	**11 427 893**	**4 414 639**

* The UNIS group consists of the University in Svalbard AS and the subsidiary companies UNIS CO_2 lab and Svalbard Integrated Arctic Earth Observing System (SIOS)

BALANCE SHEET 31.12.2019

GROUP*			University Centre in Svalbard AS	
2019	2018		2019	2018
NOK	**NOK**	**FIXED ASSETS**	**NOK**	**NOK**
		Fixed assets (tangible)		
29 253 208	31 066 208	Buildings	29 253 208	31 066 208
29 253 208	**31 066 208**	**Sum tangible fixed assets**	**29 253 208**	**31 066 208**
		Fixed assets (financial)		
-	-	Investments in subsidiary company	175 000	175 000
-	-	Sum financial fixed assets	175 000	175 000
29 253 208	**31 066 208**	**Sum fixed assets**	**29 428 208**	**31 241 208**
		CURRENT ASSETS		
41 949 796	17 689 387	Accounts receivable	4 887 551	10 950 421
12 383 138	3 817 300	Other short-term receivables	12 919 856	3 817 300
44 428 647	42 455 280	Cash and bank deposits	43 418 608	40 691 343
98 761 581	**63 961 967**	**Sum current assets**	**61 226 015**	**55 459 064**
128 014 789	**95 028 175**	**SUM ASSETS**	**90 654 223**	**86 700 272**
		EQUITY		
		Accumulated equity		
100 000	100 000	Share capital	100 000	100 000
1 954 025	1 954 025	Other accumulated equity	1 954 025	1 954 025
2 054 025	**2 054 025**	**Sum accumulated equity**	**2 054 025**	**2 054 025**
		Retained equity		
25 023 374	13 614 654	Other equity	25 147 838	13 719 946
25 023 374	**13 614 654**	**Sum retained equity**	**25 147 838**	**13 719 946**
27 077 399	**15 668 679**	**Sum equity**	**27 201 863**	**15 773 971**
		LIABILITIES		
		Allowances for liabilities		
3 400 000	3 400 000	Provisions for liabilities	3 400 000	3 400 000
3 400 000	**3 400 000**	**Sum allowances for liabilities**	**3 400 000**	**3 400 000**
		Other long-term liabilities		
12 693 277	14 520 449	Housing loan	12 693 277	14 520 449
12 693 277	**14 520 449**	**Sum other long-term liabilities**	**12 693 277**	**14 520 449**
		Short-term liabilities		
42 137 580	15 346 753	Accounts payable	15 995 926	9 650 294
2 894 525	2 887 935	Public fees and duties	2 788 749	2 811 433
39 812 007	43 204 360	Other short-term liabilities	28 574 407	40 544 126
84 844 113	**61 439 048**	**Sum short-term liabilities**	**47 359 082**	**53 005 853**
100 937 390	**79 359 497**	**Sum liabilities**	**63 452 359**	**70 926 302**
128 014 789	**95 028 176**	**SUM EQUITY AND LIABILITIES**	**90 654 222**	**86 700 273**

* The UNIS group consists of the University in Svalbard AS and the subsidiary companies UNIS CO_2 lab and Svalbard Integrated Arctic Earth Observing System (SIOS)

ARCTIC BIOLOGY

August 2019: bioCEED adviser Tina Dahl and associate professor Pernille B. Eidesen teach AB-201/204 students out in the field on Danskøya. Photo: Mads Forchhammer/UNIS.

BY ANNA VADER, HEAD OF DEPARTMENT

Arctic Biology (AB) provides a full one-year curriculum of undergraduate studies, as well as a range of master- and PhD level courses in biology. The department conducts research within biological climate effects, seasonality, and dynamics of species and ecosystems in space and time. Our strategy will strengthen our local, national and international scientific role, founded upon curiosity driven, high scientific competence and year-round presence in Svalbard.

At the end of 2019, the AB department consisted of three professors, four associate professors, five PhD students, two postdocs, a staff engineer and eight adjunct professors. Three new PhDs and one post doc were hired during 2019.

EDUCATION

Our aim is to be the primary study site for learning high Arctic biology through authentic experiences. Education at AB is research-based both in knowledge content and how we teach. Knowledge and skills are best mediated through student centred active learning and authentic research settings, and active involvement creates more motivated students and aid deeper learning. Based on this background AB has now developed both a bachelor research project course (AB-207) and a bachelor internship course (AB-208). The courses give insight into research at AB and activities at external institutions that provide job opportunities after the students finish their education. This provides the students with more practical experience and generic skills that might improve learning outcomes in other courses and prepare them for later careers. The educational development in the AB department is to a large extent linked to the project *bioCEED*, the Centre for Excellence in Education (see separate chapter).

Our focus on educational development has also led to more research on education within the department. In 2019, the inter-departmental project *FieldPass* was funded by the Norwegian Agency for International Cooperation and Quality Enhancement in Higher Education (DIKU). The goal of the project is to develop and research alternative forms of assessment suitable for field related learning. FieldPass will employ one postdoc and one technician.

The Olav Thon Foundation awarded a research grant for a project which will support the development of a high-

April 2019: Associate professor Pernille B. Eidesen was awarded status as excellent teaching practitioner (ETP). Here, she receives proof of the award from rector Dag Rune Olsen at the University of Bergen. Photo: Jens Helleland Ådnanes/UiB.

arctic, interdisciplinary field laboratory for teaching and research. To include students in field-based research activities requires more planning and resources than ordinary teaching. The goal is therefore to establish measurement stations close to Longyearbyen, for obtaining a variety of parameters, that are relevant for understanding both single components and relationships in an ecosystem. All data collected, small and large, will be available in a common database, and eventually made available through SIOS *(Svalbard Integrated Arctic Earth Observing System).*

In 2019 AB associate professor Pernille Bronken Eidesen received the status of excellent teaching practitioner (ETP). She was one of two candidates who were awarded the ETP out of 11 applications from UiB and UNIS. Pernille Bronken Eidesen is now part of the Pedagogical Academy and the purpose of the academy is to raise the quality of education through a collegial and collaborative teaching and learning culture.

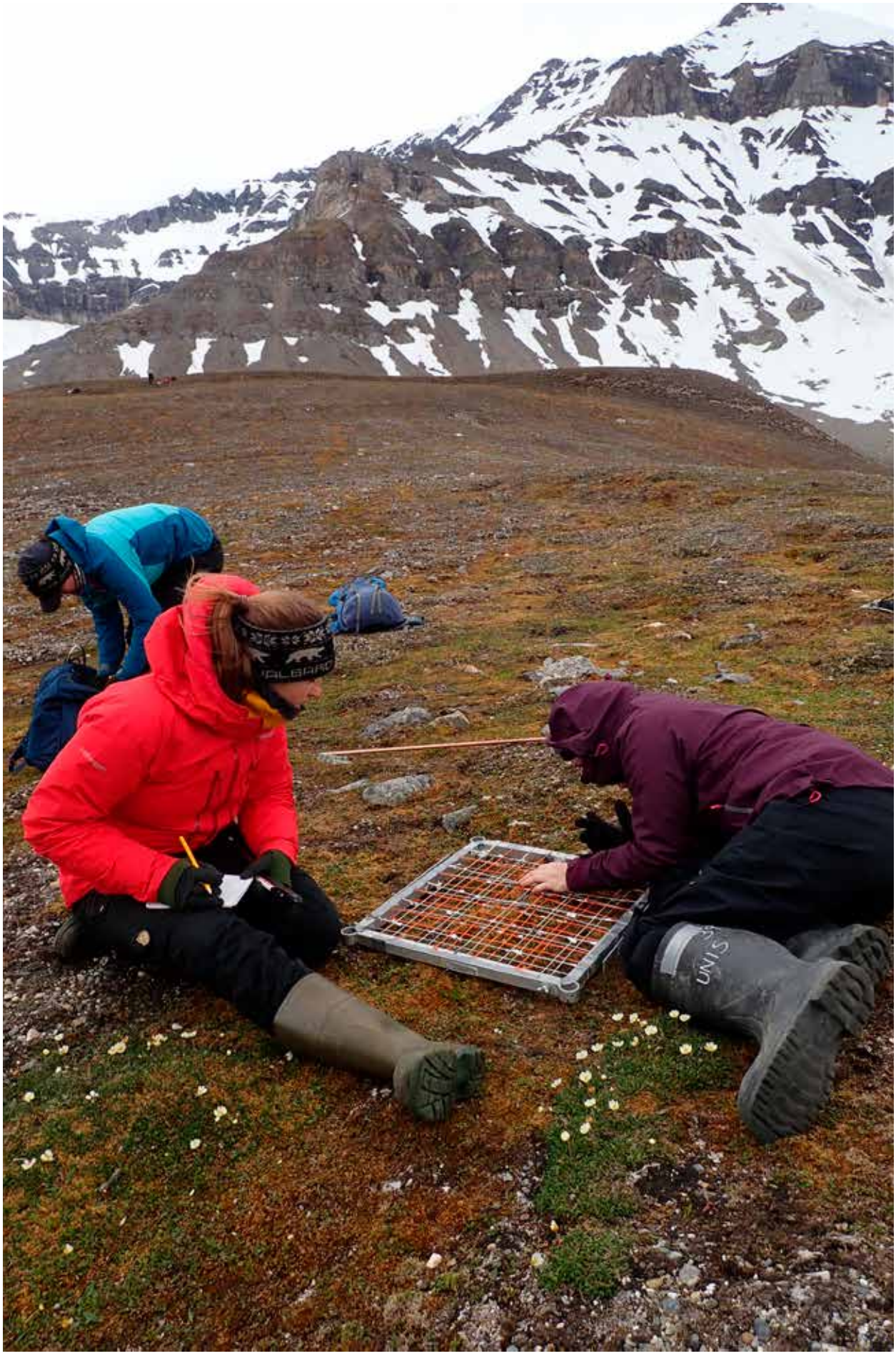
RESEARCH

The overall aim of the AB department is to become a leading institution in high Arctic biological research with cutting edge methodology and infrastructure. Our goals embrace advancing fundamental knowledge on the ecology and evolution of Arctic species, formed by seasonal as well as long-term interactions with the biotic and abiotic components characteristic of the Arctic environment, including human impact. Our research covers three over-arching interlinked themes: *Climate change biology, Seasonal ecology and Spatio-temporal dynamics of species and systems.*

The department is partner in numerous projects, including largescale projects that embrace several research aspects and many faculty staff. On the marine side the *Nansen Legacy* project (see separate chapter) was one of the departments major activities in 2019. The project has already led to several new external positions at AB.

The departmental initiative BIG *(Bjørndalen Integrated Gradient)* was continued and expanded in 2019. BIG is a supersite concept that includes all faculty staff and all habitats along an axis from the terrestrial site in Bjørndalen outside Longyearbyen, to the nearby shore areas and the IsA (Isfjorden-Adventfjorden) marine time series station. Both BIG and the Nansen Legacy projects are attempts at increasing cross-disciplinary collaboration within and outside the department. In addition, BIG includes both educational and research approaches, including research on didactic topics such as field education.

Examples of ongoing activities within BIG include automated monitoring of plant phenology and plant-pollinator interactions with time-lapse cameras. One set of cameras monitors *Dryas octopetala* (Mountain avens) as part of a large circumpolar project led by Aarhus University. This project uses state-of-the-art machine learning and computer vision methods to study the role of climate in plant-pollinator interaction with unprecedented accuracy at a range of arctic field sites. Another set of cameras monitors *Silene acaulis* (Moss campion) to investigate how the *timing* of flowering and pollinator activity affects reproductive output.



July 2019: AB-326/826 students on fieldwork in northern Spitsbergen. Photo: Simone Lang/UNIS.

This UNIS-led project has so far collected more than 3 million pictures from three different locations (Svalbard, Greenland, and mainland Norway).

Polyploidy is an important driver for evolution and speciation, particularly in the Arctic. A model system for autopolyploidy-research established in 2018 was further extended into BIG in 2019. Using *Saxifraga oppositifolia* (Purple saxifrage) as model species, the aim is to understand the evolutionary consequences of autopolyploidy. This model system generated two master theses and two bachelor theses in 2019.

Permafrost in arctic regions is under severe threat in times of climate change. Also, vegetation, which plays an important role in insulating soils, is expected to undergo significant changes. In 2019, several monitoring sites were established as part of BIG and in Adventdalen to record vegetation changes over time, and to study the influence of vegetation on the development of active layer depth. Sites encompass contrasting plant communities, from barely vegetated sites to well-developed moss tundra. Loggers were set out to record soil temperature and vegetation composition, including mosses which are important actors in insulating soils.

In 2019, AB initiated a seasonal reindeer project in Bjørndalen as part of BIG. We know very little of how the Svalbard reindeer seasonally use the landscape. The reindeer in Bjørndalen are counted on foot every week as well as being recorded by an automated network of time-lapse cameras. The time-lapse cameras also record snowmelt and reappearance of the vegetation. In 2019, the Bjørndalen population increased from 35 animals in March to 142 in July. The spatial distribution of the reindeer followed both snowmelt and vegetation appearance, with snowmelt being more important in the beginning of the season.

The AB department also participates annually in the capture-recapture of reindeer in Reindalen and the total count of the reindeer population in Adventdalen. Both populations have increased considerably over the last 40 years. However, the reindeer is particularly sensitive to winters with increased icing with following high winter mortality.

On the marine side acoustic mapping of the nearshore bottom topography and macroalgae coverage was conducted in 2019 by use of Norbit integrated wideband multibeam sonar (iWBMS) 200-700kHz. In March, AB students filmed underwater and dredged for macroalgae to study the habitat type and the kelp biodiversity in Bjørndalen.

The IsA (Isfjorden-Adventfjorden) marine time series station high-resolution marine time series station is the marine endpoint of the BIG gradient. The station was established in 2011 and aims to determine temporal drivers of microbial and zooplankton communities and to monitor and predict climate induced ecosystem changes. Time-series stations, such as IsA, are essential in telling apart natural year to year variation and long-term climate related alterations. Data on hydrography as well as diversity and community composition of microbial eukaryotes and larger plankton is collected monthly. Analyses of biological data from multiple years show both recurring seasonal patterns of biodiversity and species composition, as well as large interannual variation linked to inflow of "warm" Atlantic water. The bacterial communities at IsA were included in the time-series in 2019, as part of an ongoing master thesis.

To obtain a more holistic understanding of the "sea climate" in Isfjorden, AB also surveys the deeper marine station IsK (Isfjorden-Karlskronadjupet) located in the middle of Isfjorden. Here, PhD student Maja Hatlebakk did a monthly study for an entire year in 2015-2016 on the population development and physiology of the key zooplankton species *Calanus glacialis* and *C. finmarchicus* which are regarded as climate indicator species for Arctic and Atlantic Waters respectively. Maja defended her PhD successfully in November 2019 and her interesting findings have motivated UNIS to continue monitoring the IsK marine station.

Arctic coastal ecosystems are changing as climate changes and human activities increase. Thus, government managers, industries, conservation organizations and communities need timely biodiversity and ecosystem status data and, if possible, plausible projections of status of biodiversity and ecosystem services over the next decades. The AB focus on coastal ecosystems has led to several new projects which UNIS leads or is a major partner of.

The NIVA led project *TerrACE - Where land meets sea: Effects of terrestrial inputs on contaminant dynamics in Arctic coastal ecosystems* (NRC 2017-2020), studies riverine impacts on Isfjorden with high spatial resolution during the summer season. It includes studies of hydrography and physical properties, plankton, benthos, food webs and pollutants (mercury and POPs). The intensive and demanding field work conducted in summer 2018 resulted in six successful master theses graduations in 2019 of which four were UNIS AB guest master students. In 2019, an add-on project entitled *FreshFate: Freshwater inputs to Svalbard's coastal waters: Fluxes, fate, and implications for coastal ecosystems* (Fram Centre 2019-2021, also led by NIVA) was initiated with two new master students involved.

The large international project *ACCES - De-icing of Arctic Coasts: Critical or new opportunities for marine biodiversity and ecosystem services* (Biodiversa and Belmont forum) officially started in 2019. ACCES comprises a strong pan-Arctic and multidisciplinary team from Norway, Poland, Canada, USA and Denmark, and is coordinated and led by UNIS. This project will synthesize existing environmental and biodiversity data and generate new knowledge from sites spanning over a wide geographical scale from the Pacific to the Atlantic Arctic. In 2019, spring sea

September 2019: AB-332/832 students collecting water samples from a Niskin bottle. Photo: Malene Strøm Dieseth.

ice sampling was conducted in Van Mijenfjorden and at the East Coast (Inglefieldbukta), summer plankton biodiversity was examined during several cruises with Hurtigruten (see below) and a dedicated ACCES cruise to Storfjorden, where also macroalgae vegetation was mapped using acoustics.

Spatial resolution in biodiversity on the west and east coast of Svalbard was also addressed using Hurtigruten´s expedition ships during 2018 and 2019. This was a part of a citizen science projects funded by the Svalbard Environmental Protection Fund, where participants from AB gave lectures and demonstrations for the tourists on board, in addition to collecting marine biological data. Data collected during the 2018 Hurtigruten cruises resulted in a successful master thesis in 2019.

All these coastal initiatives led to participation in the large EU proposal *FACE-IT: The future of Arctic coastal ecosystems - Identifying transitions in fjord systems and adjacent coastal areas.* This project, led by Bremen University, was funded in 2019 and will officially start in 2020.

The *FAABulous project: Future Arctic Algae Blooms – and their role in the context of climate change* (RCN 2015-2019) ended in 2019, with the successful defence of the PhD thesis of Ane Cecilie Kvernvik. The FAABulous project studied the combined effects of altered light conditions, ocean acidification and invasion of temperate species on Arctic pelagic and sympagic algal blooms.

October 2019: AB-332/832 students working in the UNIS teaching lab. Photo: Mads Schultz.

March 2019: AB-333/833 students collecting water samples. Photo: Kirsten Christoffersen/UNIS.

GRADUATES 2019

PHD DEGREES:

MAJA KAROLINE VIDDAL HATLEBAKK
New insights into *Calanus glacialis and C. finmarchicus* distributions, life histories and physiology in high-latitude seas. *(UNIS, Nord University and Alfred Wegener Institute).*

ANE CECILIE KVERNVIK
Ecophysiological responses of sea ice algae and phytoplankton to a changing Arctic. *(UNIS, The Arctic University of Norway and Akvaplan-niva).*

MASTER DEGREE:

MAGNUS HEIDE ANDREASEN
Community composition, population structure and phylogeny of coastal sympagic meiofauna in eastern Svalbard. *(University of Bergen and UNIS).*

ANGELINE J.H.M. BRULS
Speciation in spe: Do cytotypes in *Saxifraga oppositifolia* L. (Saxifragaceae) in Svalbard differ in dispersal efficiency? *(Wageningen University & Research and UNIS).*

NATHALIE CARRASCO
Seasonality in mercury bioaccumulation in particulate organic matter and zooplankton in a river-influenced Arctic fjord (Adventfjord, Svalbard). *(The Arctic University of Norway, NIVA and UNIS).*

BEC DUNCAN
Arctic herbivore success in a changing climate. *(Murdoch University and UNIS).*

EIRIK AASMO FINNE
Flux of nutrients and mercury from an Arctic seabird colony to the coastal food web. *(University of Oslo and UNIS)*.

LOUISE C. FLENSBORG
Mammal conservation status in a changing Arctic. *(University of Copenhagen and UNIS)*.

EGIL LILLEHAUG
Environmental correlates of variation in a holistic analysis of annual offspring production in the high Arctic songbird snow bunting *(Plectrophenax nivalis)* on Spitsbergen. *(NTNU and UNIS).*

MARGOT U. NYEGGEN
Seasonal zooplankton dynamics in Svalbard coastal waters: The shifting dominance of mero- and holoplankton and timing of reproduction in three species of Copepoda. *(University of Bergen and UNIS).*

KIRSA NØRREGÅRD
A metabarcoding study on community composition of marine microbial eukaryotes in the waters around Svalbard *(The Technical University of Denmark (DTU) Aqua and UNIS).*

HELENE PAPE PEDERSEN
Conservation status of seabirds at Svalbard. *(University of Copenhagen and UNIS).*

VANESSA PITUSI
Seasonal abundance and activity of sympagic meiofauna in Van Mijenfjorden, Svalbard. (*The Arctic University of Norway and UNIS*).

ALOÏS REVÉRET
Evolutionary consequences of autopolyploidy Have a shift in substrate preferences expanded the niche of *Saxifraga oppositifolia* L.? *(Savoie Mont Blanc University and UNIS).*

STINA LINNEA EMELIE SKOGSBERG
Effects of seasonal riverine run-off on contaminant accumulation in Arctic littoral amphipods *(University of Oslo, Akvaplan-niva and UNIS).*

CHRISTIAN STOLZ
The nestling diet of Svalbard snow buntings identified by DNA. *(The Arctic University of Norway and UNIS).*

VERA TEUNISSE
Plant growth and phenological development of native plants on Svalbard in shelter. *(Vrije University Amsterdam and UNIS).*

CHARLOTTE PEDERSEN UGELSTAD
Riverine and glacier influence on infaunal benthic communities in Isfjorden, Svalbard. *(The Arctic University of Norway, NIVA, Akvaplan-niva and UNIS).*

KRISTINE VALØEN
Stochastic rain events increase NDVI through moss water content: A High-Arctic field experiment. *(NTNU and UNIS)*.

bioCEED

BY TINA DAHL, bioCEED ADVISER

bioCEED facilitates and engage in activities that aims to develop biology education to meet future needs in science and society. These activities are guided by our four focus areas: teacher culture, innovative teaching, practical training, and outreach – and are developed and lead by educational staff and students.

In 2019, many bioCEED activities have been connected to practical training and working life relevance. At the core of the bioCEED vision is that students should be exposed to a wide range of authentic learning experiences that prepare them for future working life. Such experiences are when students engage with 'real' biology in the field or lab, when they train in performing and applying biological skills and competences in relevant contexts, or when they participate alongside 'real' biologists working in research or in other workplaces.

UNISprout is one way of achieving authentic experience. UNISprout is a new student driven project lead by BSc and MSc students at UNIS. The idea is to give BSc students in biology relevant practical training through assisting MSc students, PhD students, professors or technical staff with research work. When finished, the BSc students receive a certificate on the skills acquired through the internship. The project is run through a web-based platform and the platform enables MSc students and staff to get in contact with BSc students. The project has turned out to be an effective channel for communicating internship possibilities for our BSc students.

"UNISprout provided me an opportunity to learn important scientific skills under the mentorship of an expert and to contribute to research in the Arctic. Since completing this project, I have found that these skills are directly applicable to jobs I am interested in. The experience of being trusted to work with real scientific samples, supported by a caring mentor, and being responsible for doing the careful, detailed work needed to prepare herbarium samples, built my confidence in myself and my ability to do science." **Anne Marie Colgan, BSc student, fall 2019.**

The cross-cutting interdisciplinary and student driven project *bioBREAKFAST* has also been run with great success through 2019. 147 students from our four scientific departments attended the breakfast meetings, sharing and discussing education, working life relevance and scientific career opportunities.

In 2019 the first work placement course was offered at UNIS. The 15 ECTS bachelor course AB-208 *Internship in Arctic Biology* was successfully run for the first time in spring. Five students had internship at five different workplaces in Longyearbyen (UNIS AB department, SIOS, Polar Permaculture, bioCEED and Longyearbyen school). While the students' main task was to work for and with local employers, the course also involved participation in seminars and reflection and documentation of their internship experience.

December 2019: BSc students Anne Colgan and Sari Elena Dötterer leave behind them over 100 bryophyte and lichen samples neatly packed in herbarium vouchers and two exhibition boxes. Photo: Simone Lang/UNIS.

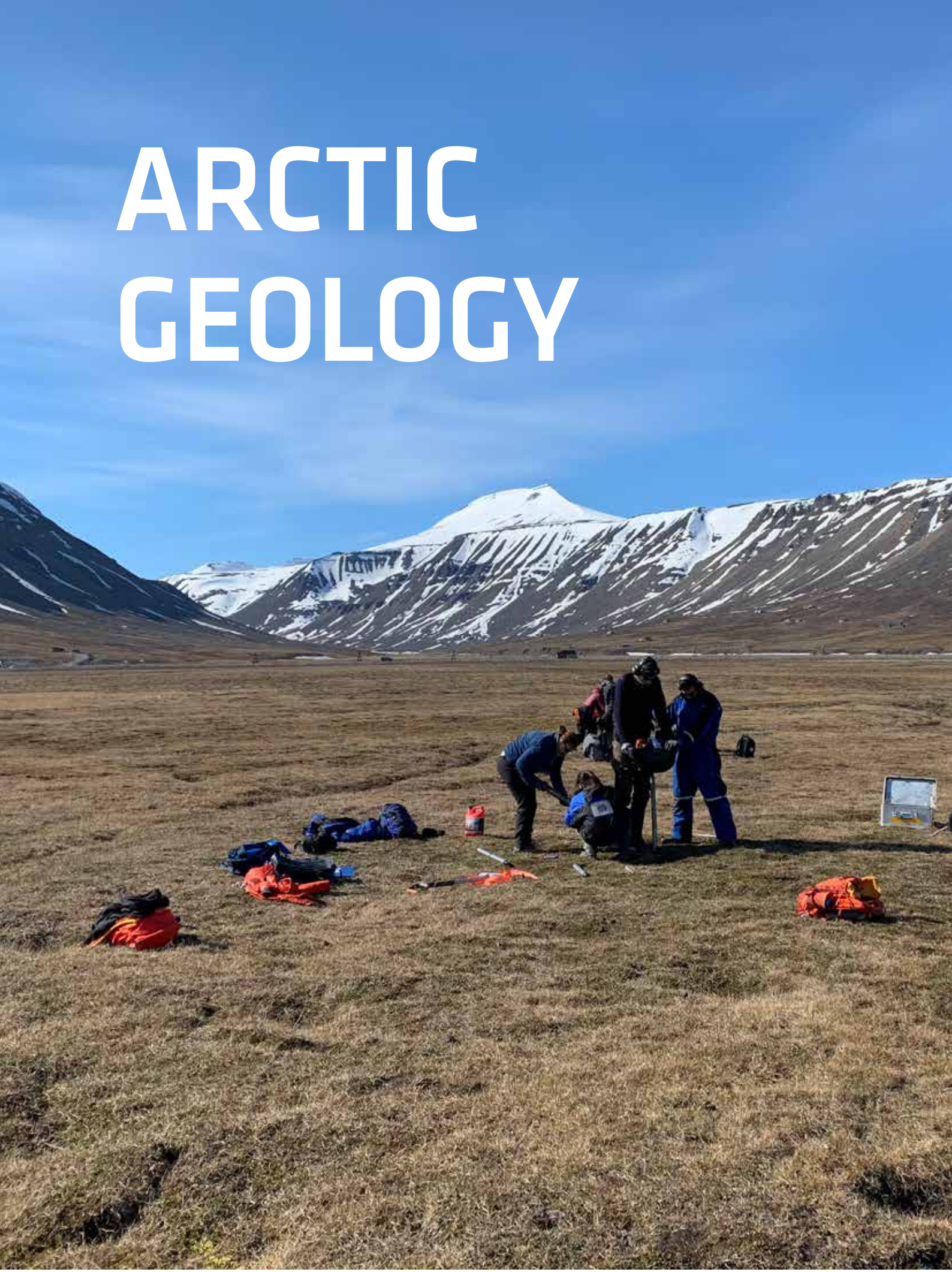
"I have also worked on more general skills, such as analytical thinking, organizational skills and co-operating with colleagues. These skills will be valuable for me in my future job no matter what job it is". **Anna Grimsby – intern technician at the AB department, spring 2019.**

ABOUT BIOCEED

bioCEED is a Centre for Excellence in Biology Education, led by the University of Bergen in collaboration with UNIS, the Institute of Marine Research and other partners.

More on https://bioceed.w.uib.no/

ARCTIC GEOLOGY



June 2019: Students on permafrost fieldwork in Adventdalen. Photo: Graham Gilbert/UNIS.

BY HANNE H. CHRISTIANSEN, HEAD OF DEPARTMENT

The Arctic Geology (AG) department's research and education is focused on the geological evolution of Svalbard as recorded in spectacular geological sequences spanning from the Precambrian to the Cenozoic and overlain by Quaternary glacial and interglacial deposits. Easily accessible outcrops make it possible to do research in the interplay of continental drift with tectonic, glacial, periglacial, coastal, fluvial and marine sedimentary processes.

The close proximity of present-day geological, glacial, periglacial, marine and terrestrial processes provides an exciting field laboratory as the basis for our research and education within three main areas: Arctic Basins, the Quaternary and the Cryosphere.

During 2019 the department had nine full time faculty positions, which were filled by four professors and four associate professors.

EDUCATION

Eight bachelor courses and eight combined master and PhD courses were taught in our department in 2019. We had large numbers of qualified applicants for many courses, but only had waiting list for a few courses. The geology department was responsible for 27 % of all student production at UNIS in 2019. In total 66.7 student years were produced in our department, of which 6.2 were from master thesis studies. Unfortunately, we have seen a decline in the amount of master students.

In 2019 we offered for the second time a full study year for geology bachelor students and one semester for physical geography bachelor students. Now only the Quaternary geology bachelor package, which already consists of a full two course, need some revision to achieve even closer integration.

The DIKU funded project *A Digital Learning Environment for field-based geoscience teaching* led by Maria Jensen is exploring the use of digital platforms in geology education and focus on integrating classroom and field teaching in a seamless way through using Ipads and an in-classroom Smartboard. The digital setup allows students to bring material and datasets worked on in advance into the field and to work directly on field data in the classroom afterwards. The idea is that this integration will allow for better alignment between field- and classroom activities, better assessment of the entire course content, more student directed learning in the

field and a better chance to catch misunderstanding or problems from fieldwork in classroom discussions.

We have been active in the national consortium *Centre for integrated Earth System education* (iEarth), planning a Centre for Excellence in Education (CEE) application. AG has been developing the UNIS led focus on field teaching in iEarth with other UNIS colleagues, been at the iEarth site visit as the final part of the evaluation for CCE application and been involved in designing and running the first iEarth GeoLearning Forum. iEarth received CEE funding in December 2019.

We are involved in the new DIKU funded multi-departmental project *FieldPass* led by the Arctic Biology department, to further develop the field education at UNIS with respect to course alignment within all our bachelor courses.

Several staff members also in 2019 participated in the educational offer for natural science students in the Arctic Safety Centre teaching and in the development of a local awareness society in Longyearbyen also part of the Arctic Safety Centre.

The AG-351/851 course on Arctic Volcanism and Tectonics was run for the first time in the summer. 14 students from around the world attended the course and learned to decipher the tectonic evolution of the Arctic with hands-on support from a number of experts.

RESEARCH

The department has three specialised research groups, presented below with their different main activities. However, also cross departmental research is going on and are being planned.

Arctic Basins

The *Research Centre for Arctic Petroleum Exploration* (ARCEx) continued to be a major research-driver in the department, as evident by the s intense activity and scientific output in 2019. UNIS is an active partner in ARCEX, with Kim Senger co-leading the geology work package and adjunct Professor Tor Arne Johansen leading the Eco-safe exploration work package. PhD student Tom Birchall is fully funded by ARCEx, while several UNIS-based and external PhD students are affiliated with ARCEx. The geology work package strives to provide a better basis to assess the petroleum potential in the northern Barents Sea by systematically working to reduce the geological risk factors including presence and quality of reservoirs, source rocks and traps. Birchall's research on the underpressure development in Svalbard sparked much interest and is of utmost importance for ongoing exploration drilling across the Barents Shelf.

A milestone achievement was the publication of the special volume entitled "Going deeper" of the Norwegian Journal of Geology (vol 99) based on the results from the Longyearbyen CO2 Lab. The collection of eight scientific papers and a comprehensive bibliography testifies to the immense learnings associated with the project – 13 PhD students, 27 MSc students and almost 70 peer-reviewed publications resulted from the effort (so far). In a climate perspective the main achievement of the studies is that it has shown unconventional fractured reservoirs are suitable for storing CO_2. Apart from the de-risked possibility of the aquifers as CO_2 storage units and top seal, the studies have; i) revealed improved age and sequences of large part of the Mesozoic succession in Svalbard, ii) enhanced knowledge of fractures as fluid flow in the subsurface, iii) better constrained rock temperature gradient in Adventdalen and iv) established the deglacial history of Adventdalen. Due to absolute dating from a volcanic ash layer in one of the wells in Adventdalen combined with a complete cored succession of the Lower Cretaceous, the global boundary between the Barremian Aptian will be changed in the global Geological Time Scale. Some unexpected results were also obtained, including; i) severe underpressure of approximately 50 bar; ii) discovery of gravity-flow deposits attributed to so far unknown Hauterivian clastic wedge and iii) detection of producible thermogenic shale gas at a depth of 640 to 700 m.

UNIS and the coal-mining company SNSK joined forces to safeguard physical and digital material collected during various geological campaigns in Svalbard in the project *Svalbard Rock Vault* funded by the Svalbard Science Forum. Activity in 2019 centred on cataloguing the existing physical drill core material in Longyearbyen and Svea, as well as digitizing the archive material provided by Norsk Polar Navigasjon to UNIS. In addition, other relevant archives and core repositories were visited, giving us a clearer perspective of how to optimize a drill core facility for enhanced scientific input.

The project *Coal - The ice core of the warm past: Using the natural coal archive on Svalbard* to initiate a flagship for paleoclimate research is funded by a Svalbard Strategic grant from the Research Council of Norway (RCN). Maria Jensen and Malte Jochmann are leading this project aiming of obtain high resolution paleoclimatic records from coal. During 2019 unique samples were collected from the Lunckefjellet and Svea Nord mines before closing. The samples will be archived to form the basis for future paleoclimate research at UNIS. Samples have also been obtained from Mine 7, and these are used for analysis and methods development. This project's aim is to transfer competence from coal laboratories to UNIS and show the scientific potential in the coal-seams on Svalbard.

Work on the tertiary basin was carried out in the summer 2019 in Colesdalen. Here we have made virtual outcrops of the Palaeogene Aspelintoppen Formation. This formation has traditionally been difficult to do intensive work on as it is exposed on the highest mountain tops, but drone images and virtual outcrop technology have made 3-dimensional models of these deposits possible. In addition, virtual outcrops produced for research also doubles as teaching material for sites that cannot be

accessed during field excursions and for class preparation before fieldwork.

Maria Jensen obtained funding from the Svalbard Environmental Protection Fund for the project *Moving Coast*, aimed at establishing methods for InSAR analysis of coastal movements in the Svalbard area on a cm-scale. This adds to the ongoing project *DynaCoast* (collaboration between UNIS and NGU) where detailed mapping of the morphology and dynamics of the coastal zone in Isfjorden is being carried out. This work has documented a highly dynamic coastal system, and the ability to monitor coastal change also in remote locations will help with environmental protection and planning and also provide new insight into the different coastal responses to climate and sea level change in different parts of Svalbard.

Marine and Quaternary geology

In 2019, Riko Noormets continued his research into the glacial and environmental history of Svalbard and the Barents Sea together with colleagues and students. The glacier calving processes and their geologic imprint on the seafloor were studied using autonomous mapping tools at different tidewater glaciers. Building on this long-term collaboration, Noormets became an affiliated professor at Stockholm University and was awarded an ASIAQ grant in support of developing autonomous tools for marine glaciological research in the Arctic together with Stockholm University and The Royal Institute of Technology (KTH).

Lena Håkansson has continued the project *Holocene Precipitation Seasonality in Svalbard* with the purpose to reconstruct Holocene hydroclimate by analysing leaf wax hydrogen isotopes in lake sediment cores. She has been involved in the *PolarCH4ives* project using ancient eDNA in lake sediment archives to characterize CH_4 exchange in Arctic catchments during periods of major climatic change since the last glaciation. In September Håkansson hosted a workshop on field learning for previous master students at UNIS. Håkansson has been involved in the development of iEarth where she is leading a progress domain on field learning.

Mark Furze continued his research into the deglacial history of Svalbard with the development of the SHERBET *(Svalbard Holocene Elucidation of Raised Beach Emergence and Timing)* project focussing initially on the Erdmannflya region of Isfjorden. This project aims at improving records of Holocene sea-level change in response to isostatic unloading during and following deglaciation coupled with improved chronology. He also began developing a related project SLEIPNIR *(Studying Landsystem Evidence for Ice-margins in the Pleistocene Nordenskiöldland - Isfjorden Region)*. He has continued to work on projects stemming from his prior research in Arctic Canada on the deglaciation of the Northwest Passage and paleo ice shelf development and collapse including work with partners at ArcticNet (Canada).

Martin Jakobsson carried on his work as the vice chair of GEBCO and a co-leader of the North Pacific and Arctic Ocean regional centre of the Nippon Foundation-GEBCO Seabed 2030 Project (https://seabed2030.gebco.net). As part of global seafloor mapping initiative, work continued on the next version of the Arctic bathymetry, the IBCAO v.4, that will be released in 2020.

Mike Retelle hosted a workshop with colleagues from UNIS, U.S., the Russian Scientific Centre on Spitsbergen, NORCE and the Polish Polar Station in Hornsund to develop a contribution to the 2019 Status of Environmental Science in Svalbard (SESS) report by SIOS. The contribution built on interdisciplinary research in hydroclimate, limnology, glaciology, surface processes and permafrost in the newly established Kapp Linné Environmental Observatory, a multidisciplinary international collaborative research initiative effort.

Heather Bell commenced her PhD "Investigating signatures of collapse and retreat of the Svalbard-Barents Ice Sheet" in 2019.

The cryosphere

Members of the Cryosphere research group were involved in two new projects funded by the RCN and led by Andy Hodson. The first, *Blue Ice Oases of Microbial Life on the Antarctic Ice Sheet* (BIOICE) commenced in 2019 by hiring postdoc Aga Nowak. In collaboration with the Norwegian Polar Institute, fieldwork was done at the Troll Station, Antarctica, collecting ice cores and other samples that will be used to understand the revival of microorganisms in Antarctic ice as it is advected to the warmer margins on the ice sheet. The second project: *Climatic forcing of terrestrial methane gas escape through permafrost in Svalbard* (CLIMAGAS) also commenced in 2019 and involves Kim Senger and Peter Betlem from the Arctic Basins group. Research assistant Mikkel Toft Hornum began developing new modelling tools for understanding the migration of methane-rich groundwater beneath permafrost. Fieldwork also involved geochemical sampling of groundwater springs across the entire Nordenskiöldland area, leading to some new discoveries of methane-rich outflows in both Reindalen and Grøndalen. Co-investigators from the Arctic University of Norway and University of Bergen also began conducting novel work on the microorganisms responsible for both the production and the removal of the methane in these springs.

The cryosphere group is also actively involved in the *Svalbard Integrated Arctic Earth Observing System* (SIOS) - Infrastructure development of the Norwegian node, InfraNOR, national infrastructure project funded by the RCN, which had its first full operational year in 2019. UNIS is responsible for upgrading the permafrost observation infrastructure in this project around Longyearbyen and in the Kapp Linné areas, with Hanne H. Christiansen as responsible. In spring 2019 a 45-day long permafrost drilling campaign extended and upgraded nine of the now more than 10-year

February 2019: UNIS geologists Maria Jensen and Malte Jochmann, together with Chris Marshall from the University of Nottingham, collected coal samples from the Lunckefjell mine before it was shut down. Photo: Rolf Stange.

old permafrost boreholes drilled and instrumented during the IPY (2007-2008), which now reach down 21 m. In total 167 m drilling was done and we collected permafrost drill cores from 64 m of the 167 meters drilled. Seven of the boreholes were cased and in autumn new instrumentation was installed. We plan for online access to the borehole data. We are also improving our permafrost drill rig to be able to core the different types of sediment existing in Svalbard. We collaborate with the Norwegian Meteorological Institute (MET) who is responsible for establishing permafrost boreholes in more remote parts of Svalbard in InfraNOR using the UNIS permafrost drill rig. In summer our UNIS based permafrost drill rig drilled a 20 m permafrost borehole in close collaboration with MET at Verlegenhuken in the northernmost part of Spitsbergen.

Hanne H. Christiansen led the project *Permafrost temperatures and active-layer thickness in Svalbard during 2017/2018* (PermaSval), funded by SIOS. The aim was to update the first regional analyses of the observations of the permafrost ECVs (essential climate variables), the permafrost thermal state and the active layer thickness as observed in Svalbard for the period 2017-2018 into a contribution to the SESS report. Partners from Italy, Russia, Poland, Germany and Norway all with permafrost observation infrastructure in Svalbard participated in this work. The project presented data from the Longyearbyen, Kapp Linné, Barentsburg, Ny-Ålesund and Hornsund areas.

PhD student Sarah Strand worked on collecting more permafrost ground thermal data from the UNIS monitoring infrastructure and was in charge of making a new mountain valley borehole at Frithamn as part of the expanded SIOS InfraNor observation infrastructure.

PhD student Holt Hancock continued monitoring the cornice systems in Longyeardalen using terrestrial laser scanning in addition to field observations of snow and avalanche conditions throughout Nordenskiöldland. The DRIVA snow sensor project – a collaboration between UNIS and Telenor – has worked to develop and install a network of low-cost snow depth sensors in locations where avalanches threaten infrastructure and/or heavily trafficked snowmobile routes in and around Longyearbyen. This project is funded by the Arctic Safety Centre (ASC) and is part of the local awareness activities of ASC.

RESEARCH ADMINISTRATION

Maria Jensen participates in the Kongsfjorden flagship group under the Ny-Ålesund Science Managers Committee (NySMAC), and was involved in developing a pilot project for collaboration between terrestrial and marine biologists, geophysicists and onshore geoscientists to study land-sea transects in Kongsfjorden and the influence of long- and short-term sediment dynamics on ecosystems.

The International Permafrost Association (IPA) Secretariat had its third full year of operation at UNIS, being run by Executive Director (PhD student) Sarah Strand, and with Hanne H. Christiansen as President of the IPA. The first Southern Hemisphere Conference on Permafrost (SouthCOP) was the major event in 2019; organized and held in New Zealand with more than 100 participants.

January 2019: The first sensor of the DRIVA snow sensor project is set up on Sukkertoppen. Photo: Sara Mollie Cohen/UNIS.

Kim Senger is leading the University of Arctic (UArctic) thematic network on Arctic Geology, a platform for circum-Arctic collaboration on outreach, education and research efforts.

OUTREACH

Peter Betlem and Kim Senger used UArctic project funds to build up the Svalbox database, an online portal integrating existing geoscientific material with new virtual outcrop models collected by UNIS. In addition, they set up a virtual reality (VR) system that allows geologists to visit outcrops without leaving UNIS – and they even tried the system on the Minister of Education and Research Iselin Nybø when she visited UNIS in May 2019.

GRADUATES 2019

MASTER DEGREE:

TENNA SIMONE CHRISTIANSEN
Shallow seismic imaging below frozen ground in the Arctic. *(University of Copenhagen and UNIS).*

EMMA CIRIC
Methane escape features in coastal sediments exposed by isostatic rebound. *(University of Algarve and UNIS).*

URSULA ENZENHOFER
Influence of distributed snow and firn cover evolution on the glacier surface mass change on a high elevation snow field. *(University of Natural Resources and Life Sciences, Vienna and UNIS).*

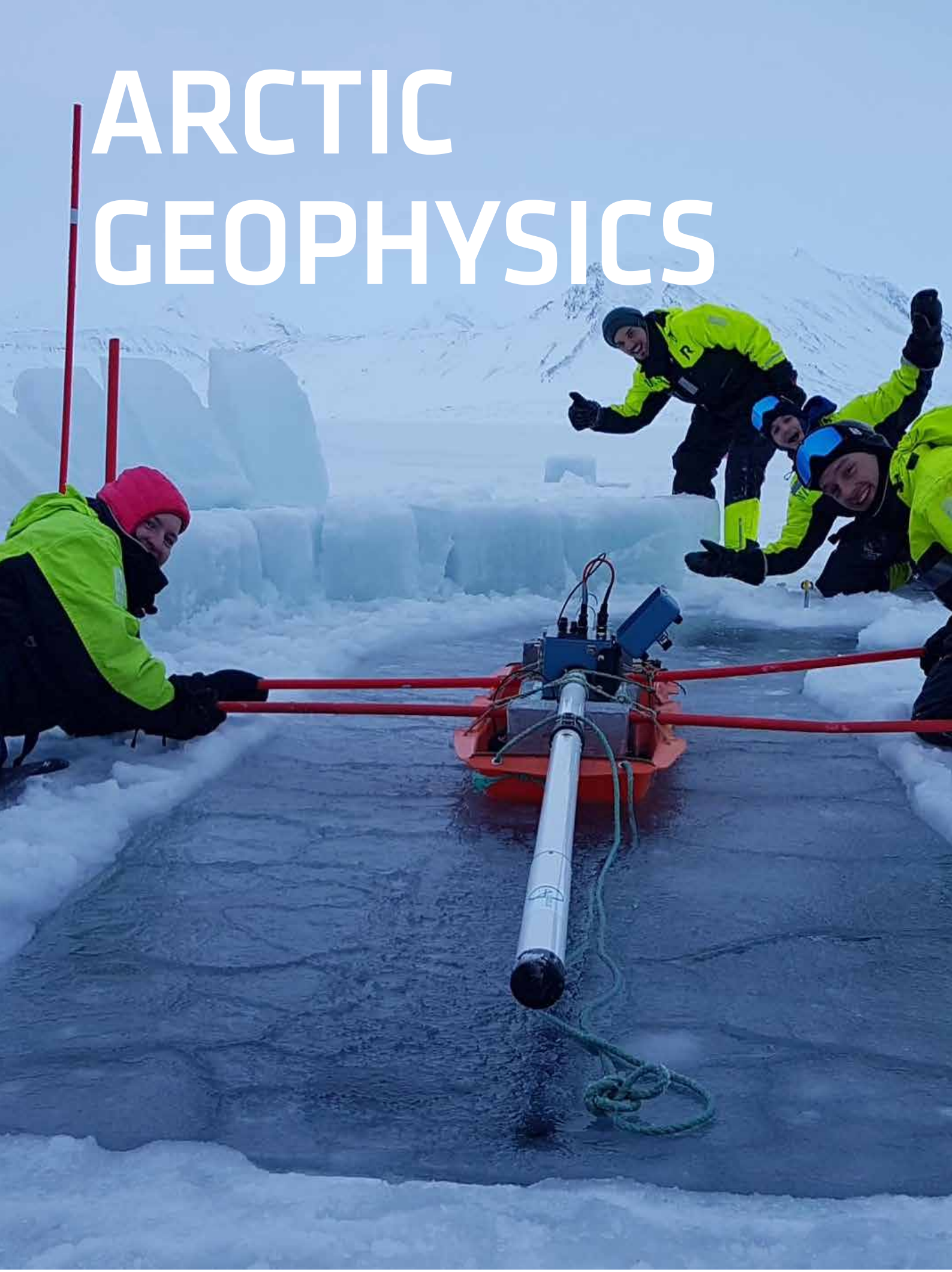
SONDRE HAGEVOLD
From outcrop to synthetic seismic: 2D and 3D modelling of igneous intrusions at Botneheia, central Spitsbergen. *(University of Bergen and UNIS).*

ELISABETH OSALAND
Petrography, geochemistry and sedimentology of sandstones from the Central Tertiary Basin of Svalbard – implications for diagenesis and temperature history. *(University of Bergen and UNIS).*

MARTIJN RODENBURG
The dynamics of the coastal sedimentary system in Adventfjorden in Svalbard, Norway. *(Vrije University Amsterdam and UNIS).*

MAXIMILIAN WEBER
Paleoenvironments during the Paleogene in the High Arctic of Spitsbergen – Evidence from Sedimentology and Palynology. *(Technical University of Darmstadt and UNIS).*

ARCTIC GEOPHYSICS



April 2019: Happy AGF-211 students on fieldwork in St. Jonsfjorden. Photo: Lars Henrik Smedsrud/UNIS.

BY DAG A. LORENTZEN, HEAD OF DEPARTMENT

The Arctic Geophysics departments two research groups conducts research and education in the column from sub-sea to near space.

The department had at the end of 2019 eight full time faculty in the fields of oceanography, meteorology, and space physics. The department also had two post docs and one project research scientist, eleven adjuncts and six PhD's. In addition, two engineers are working in the department.

EDUCATION

Courses are offered in all the research fields within the department. In 2019, seven Bachelor courses and six Master/PhD courses were given. Some of the courses are combined into semester packages; the department offer one full semester bachelor package and one full semester master/PhD package during the spring term, and two full semester bachelor packages during the fall term. All courses include a field work component, either in a location out in the field, a research cruise or in a field station/observatory. In 2019, AGF-319/819 *Shipping in the Arctic,* was run as a master/PhD course for the first time. 11 students (6 master and 5 PhD) took the successful course. This course is an interdisciplinary course providing lectures on climate, sea ice, weather, environment, navigation, technology, infrastructure, economy, regulations, and geopolitics related to shipping in the Arctic.

RESEARCH

Space physics

The space physics group is part of the *Birkeland Centre for Space Science* – a centre of excellence in space physics which is based at the Univ. of Bergen. The space physics group operates two large scale research facilities, the Kjell Henriksen Observatory (KHO) and the SuperDARN radar. At KHO, the activity has been high in 2019 with several events. The observatory hosted two high profile visits by the Norwegian Minister of Education and Research and the US Ambassador to Norway. Preparations for the auroral season were hectic with painting, fixing water leaks from the domes and water supply maintenance. KHO is still attractive to the space science community with 24 external groups from 14 nations present. Our tracking system with 4 cameras is operational and tested successfully. Three rockets have been launched as part of the Grand Challenge Initiative (GCI) with vital ground-based support from KHO. Parts of the space physics group also provided ground support from EISCAT during the GCI campaign in November/December 2019. The space physics group has also been working on the planning for rebuilding the antenna arrays of the SuperDARN radar that broke down due to heavy ice and wind loads in fall 2018, and this project is on track.

November 2019: The rocket ICI-5 (part of the Grand Challenge Initiative) was launched from Ny-Ålesund. This photo is taken on Breinosa outside Longyearbyen. Photo: Martin Langteigen/EISCAT.

The RCN *PolarProg* project (which is a collaborative project between scientists at UNIS and in Russia) was completed at the end of 2019. The project investigated modulations in ionospheric parameters (such as temperatures, densities and auroral brightness) caused by various coupling mechanisms such as that which occurs between the Earth's magnetic field and Suns (the Interplanetary Magnetic field). Data from a variety of instruments across Svalbard (including the KHO) were used, along with supporting satellite datasets. The project was a great success with eight exchange visits, presentations at eight national and 20 international meetings, one dedicated session at the 2018 EGU meeting and 10 publications in international peer reviewed journals. An application has been submitted the Research Council of Norway's INTPART call for funding to continue and extend the project to include more datasets and additional researchers.

The algorithm looking at flow channels across the polar cap has been successfully applied to one year of the Svalbard SuperDARN radar and detected over 500 events. The statistical study indicates a significant population of flow channel events associated with dayside reconnection processes which is the subject of ongoing work. Two case studies were examined in detail and, although the channels are considered mesoscale phenomena inside the ionospheric polar cap it was found they can account for 60% of the total cross polar cap potential (which is an indictor as to the strength of the overall convection inside the polar cap and can be thought of as a proxy for the coupling efficiency between the solar wind and geomagnetic field).

The middle atmosphere team of the space physics group focuses on detection and characterization of particle precipitation, and studies of the effects of high-energy particle precipitation on the Earth's atmosphere. In December 2019, Erkka Heino defended his PhD thesis on solar proton impact in the Earth's atmosphere. The studies in the thesis clearly show that the current implementation of the solar proton impact area in the climate models is significantly overestimating the region where energetic solar protons can access the atmosphere. Due to their high energies, the protons cause strong ionization and consequently a large-scale depletion in the stratospheric ozone, which can last for several days. It is thus important to improve the description of the proton impact area for the future atmosphere and climate modelling efforts in order to more accurately estimate the natural climate variability. Another highlight of the year is that the new SuperDARN method to detect energetic particle precipitation with the sudden attenuation of received power and sky noise can not only be used to monitor solar protons but successfully detects energetic electrons as well. This will provide another important tool to improve the energetic particle forcing in the climate models.

Air-Cryosphere-Sea Interaction

The meteorology section has the co-lead on the four-year RCN funded project *Advanced models and weather prediction in the Arctic: Enhanced capacity from observations and polar process representations* (ALERTNESS). The main aim of the project is an improved weather prediction capability for the Arctic, benefiting amongst others increased high-latitude activities related

February 2019: UNIS technician Stefan Claes working on the weather mast in Bjonapynten in Tempelfjorden. Photo: UNIS.

May 2019: AGF-352/852 students setting out a CTD onboard «Polarsyssel". Photo: Marika Marnela/UNIS.

May 2019: An AGF-352/852 student analyse water samples onboard "Polarsyssel". Photo: Marika Marnela/UNIS.

May 2019: The Russian Consul General in Barentsburg presented Professor Frank Nilsen and UNIS the Russian Ministry of Emergency Rescue medal "For good fellowship in the name of rescue". Frank Nilsen participated in the rescue operation following the tragic helicopter accident outside Heerodden in 2017. Photo: Fred Skancke Hansen/UNIS.

to e.g. shipping, fishery, transportation and tourism. The project centres on the AROME-Arctic weather model, that is operationally run for a region covering Svalbard, the Barents Sea and the northern parts of Fennoscandia. Research connected to the project has already yielded important results and lead to publications on for example verification metrics for weather models and 'rain on snow events' -events where precipitation falls as rain during winter.

UNIS and the Norwegian Meteorological Institute have signed a collaboration agreement. The meteorology team has had a central role in getting this agreement in place and one good example of ongoing work is collaboration on weather stations around Longyearbyen. The weather station by the old auroral station in Adventdalen is run in a joint effort between the two institutions and work is currently ongoing in installing a new weather station in Longyearbyen.

The oceanography team is deeply involved in the *Nansen Legacy*. The team's main delivery into the project is to provide data sets from year-long moored instruments and process cruises around Svalbard, and to study the processes contributing to the ocean heat input into the region north of Svalbard and the northern Barents Sea. See more details in separate chapter.

New national marine infrastructure has been developed through the RCN funded SIOS project *Svalbard Integrated Earth Observing System – Infrastructure development of the Norwegian node* (SIOS-InfraNor). The interdisciplinary oceanographic mooring combining physics, biology, and chemistry, have been designed in collaboration with Aanderaa Data Instruments AS and will be deployed in Isfjorden with online data access as soon as possible in 2020. This mooring, together with a surface buoy, makes it possible to reveal some of the controlling forces and possible weather conditions for warm water intrusion into the Isfjorden system. Measurements of the water column in Isfjorden during winter and spring months are necessary to evaluate the potential danger for weak sea ice and melting sea ice due to warm water intrusion. Moreover, the interdisciplinary sensor design makes it possible to monitor e.g. the spring bloom development and possible energy extraction form surface gravity waves.

Other research activities in Isfjorden during 2019 were two moorings at the fjord mouth designed to measure

exchange flow between the shelf and fjord and are both part of the field work in the bachelor course AGF-214 Polar Ocean Climate. The southern mooring has delivered valuable data sets of hydrography and current since 2005 (with a few missing years). In September, this mooring was also equipped with a new instrument with biological sensors to further enhance the interdisciplinary collaboration with the biology department at UNIS. This collaboration has already resulted in published work in 2019 based on the Isfjorden-Adventfjorden time series station (IsA), where species composition was linked to season and presence of different water masses. The northern mooring was moved further inside Isfjorden on the southern side to follow any intrusion of warm and saline Atlantic Water (AW). In addition, standard hydrographic sections were obtained in April and September during the bachelor courses AGF-211 Air-Ice Sea Interaction I and AGF-214, which have been done almost regularly since 1999. During this time period Isfjorden has experienced a dramatic climatic change with less sea ice cover and more inflow of AW both in winter and summer. This collection of UNIS data is published in 2019 as a database called UNIS hydrographic database (UNIS HD) in the Norwegian Polar Institute's data archive and is scientifically linked to a revised study of the variability and trends in the fjord's climate and circulation. Additionally, all the yearlong mooring data obtained by UNIS from the Isfjorden system over the years were published in 2019 in the same data archive and are also linked to the same study. A related study of the Kongsfjorden hydrographic transect was published as a book chapter in 2019, where the used data were published as a subset of the UNIS HD (Kongsfjorden Transect CTD data 1906-2016) in the Norwegian Polar Institute's data archive.

The chemical oceanography team published work with emphasis on the marine carbon cycle and ocean acidification from data sampled in Isfjorden and Tempelfjorden between 2015 and 2017. The physical and biogeochemical processes that govern changes in total alkalinity (TA), total dissolved inorganic carbon (DIC), and the saturation state of the calcium carbonate mineral aragonite (Ω_{Ar}) were assessed on a monthly timescale. Primary production resulted in the largest changes that were observed in the partial pressure of CO_2 (pCO_2, 140 µatm) and the saturation state of aragonite (Ω_{Ar}, 0.9). Over the period of peak freshwater discharge (June to August), the freshwater addition and air-sea CO_2 uptake governed the surface pCO_2.

GRADUATES 2019

PHD DEGREE:

YLVA ERICSON
Drivers of the marine CO_2 system in the High Arctic - from the deep basins to the shallow fjords. *(UNIS and University of Bergen).*

ERKKA PETTERI HEINO
Spatial extent of solar proton impact in the Earth's atmosphere - Observations and modelling. *(UNIS and the Arctic University of Norway).*

MASTER DEGREE:

OLA BAKKE AASHAMAR
Heavy rain events in Svalbard summer and autumn of 2016 to 2018. *(University of Oslo and UNIS).*

JOSHUA DREYER
A detailed study of auroral fragments. *(Uppsala University and UNIS).*

FLORINE ENENGL
On the relationship between energetic electron precipitation and mesopause temperature. *(KTH Royal Institute of Technology and UNIS).*

RIKKE HEDELUND HANSEN
A Comparison of Naturally Enhanced Ion Acoustic Lines and Auroral Spectral Line Emissions. *(The Arctic University of Norway and UNIS).*

CHARLOTTE M. VAN HAZENDONK
Calibration of a Hyper Spectral Imager. *(Eindhoven University of Technology and UNIS).*

MARIE BØE HENRIKSEN
Hyperspectral Imager Calibration Characterisation and Image Correction. *(NTNU and UNIS).*

SARA GASPARINI
Statistical properties of backscatter from the Longyearbyen SuperDARN radar. *(NTNU and UNIS).*

ABEL PRUCHON
Analysis of the STeP (Storfjorden Polynya multidisciplinary study program) data. *(Centrale Nantes and UNIS).*

THE NANSEN LEGACY

December 2019: Processing the benthic trawl catch onboard RV Kronprins Haakon. Photo: Snorre Flo/UNIS.

BY JANNE E. SØREIDE AND FRANK NILSEN

In 2019, UNIS participated in two major Nansen Legacy cruises in the polar night period. New information about life in the northern Barents Sea was obtained.

The Nansen Legacy is a large Norwegian research project with 10 participating institutions. More than 130 researchers are engaged in the project, of which more than half are young recruits enrolled in PhD or postdoc programmes. UNIS is strongly involved in the project and has in total six recruitment positions during this five-year long project. In addition, UNIS provide significant in-kind contributions with faculty staff and logistical support. The overall aim of the Nansen Legacy is to gain a more comprehensive understanding of the climate in the northern Barents Sea and how this in turn affects fisheries and the entire ecosystem.

Another important goal is to educate the next generation of Arctic scientists which is in line with the UNIS strategy. A total of 285 cruise days are funded through the project divided between physicists, biologists and technologists.

In the joint Nansen Legacy and A-TWAIN/SIOS-InfraNor oceanographic cruise in early November 2019, engineers and scientists from eight institutions steamed around Svalbard to service moorings, deploy a Seaglider, and make CTD profiles and transects with water samples. They successfully recovered and re-deployed the UNIS mooring between Edgeøya and Hopen that monitor possible Atlantic Water (AW) intrusion into the northern Barents Sea and the development of the sea ice cover in the region. Moreover, two new moorings were deployed east of Nordaustlandet to monitor inflow of AW from the north, between Nordaustlandet and Kvitøya.

RV Kronprins Haakon had just returned from this intensive cruise before the biologists re-loaded the vessel and turned it around again in late November. The main aim: to study the living Barents Sea during the polar night. The cruise was co-led by UNIS and The Arctic University of Norway. Winter cruises are rarely conducted in the high Arctic. It is challenging to do field operations in continuous darkness, combined with often unstable and stormy weather as well as freezing cold temperatures and sea ice formation.

The first storm hit RV Kronprins Haakon just a few hours after it left Longyearbyen. Fortunately, it got better when getting into the pack ice at around 81°N. Here the sea was frozen and thus calm. RV Kronprins Haakon has polar ice class and made good 4 to 6 knots on its way to our northernmost station at 82^0N with ocean depths of 3600 metres. Almost no data from this time of year exists and all on board were therefore very excited. It was amazing to see all the buzzing life in the ocean. We had assumed most life to be in “hibernation”, but it was measurable

December 2019: CTD was taken to collect hydrographical data from the upper 10 m of sea ice. Here UNIS PhD student Robynne Nowicki in action with assistance of research technician Anette Wold, NPI. Photo: Andreas Wolden/Institute of Marine Research.

amounts of algae, especially inside the sea ice, and zooplankton was abundant and very active. The large, fat and nutritious copepod *Calanus hyperboreus* produces up to 400 eggs. Copepod males were found in high numbers which in itself was very interesting since we rarely catch them. These males are very short-lived and are primarily present in winter. To make our way through the ice was fascinating. Several different types of ice were seen, and the frosty smoke was intense in the few open leads visible. On thin, newly formed ice beautiful frost flowers formed when the temperature dropped below minus 20C. These flowers can be up to 5 cm high and consist of fine, high-surface ice crystals that in turn gather many microorganisms. These flowers were carefully picked by the microbiologists and are currently being analysed.

Bacteria are much more abundant in sea ice than in the sea itself. Most sampling was conducted from the vessel, but the scientists also entered the sea ice to collect sea ice cores for physical and biological measurements. To be a polar bear guard and to watch sudden changes in the sea ice conditions is a challenge in the darkness, but strong ship lights and many people on watch made it safe to operate on the sea ice close to the ship. The cruise had an ambitious plan and most tasks were accomplished without any accidents. The largest challenge, however, was to sample the last and southernmost station of the Nansen Legacy transect in the Barents Sea. The strong wind and heavy swell made it impossible to sample benthos with the box corer or to deploy a drifting rig with sediment traps capturing everything that settles in the water column. The cruise ended in Tromsø 17 December.

Biological data from the polar night is of huge scientific interests since we have so limited knowledge from this time – a time period which may be one of the main bottlenecks for boreal species to establish themselves in the high Arctic.

More about the Nansen Legacy on https://arvenetternansen.com

ARCTIC TECHNOLOGY

March 2019: Arctic technology researchers on fieldwork in Svea. Photo: Nataly Marchenko/UNIS.

BY ARNE AALBERG, HEAD OF DEPARTMENT

The Arctic Technology (AT) department offers courses and performs research within two main fields. Arctic Engineering concentrates on engineering problems related to settlements, structures and operations in the Arctic environment, foundations and structures in the frozen ground, loads from the physical environment, like waves, ice, and snow forces, material behaviours, rock fall, and landslides and avalanches, Arctic offshore oil and gas exploitation and potable water supply. Arctic Environmental Technology concentrates on current and potential pollution problems, environmental impacts and feasible remediation techniques in Arctic areas.

In 2019, the department had two professors and one associate professor, one research associate, one PhD candidate, one staff engineer, and an adjunct staff of seven professors.

EDUCATION

Our research activities support and motivate the education in the department's courses at all levels, by generating data and measurements series on physical and mechanical properties of ice and soil, time dependencies and failure modes of such materials, as well as pollution contaminants and concentrations onshore and offshore. This gives students the opportunity to study both the theoretical and practical aspects of Arctic technology, engineering and environmental technology, and further to benchmark analytical and numerical models and simulations, in order to provide better assessments and predictions for Arctic infrastructure and contribute to a sustainable environment. In 2019, the department offered two courses at bachelor level, and 17 courses on master- and PhD level. Two courses have annually large fieldwork projects in Svea and provide valuable research data for several projects. In another course very popular fieldwork is on full scale rockfall testing from mountains around Longyearbyen, and subsequent simulations with a commercial computer program in order to calibrate parameters for the arctic conditions. This activity is done in close cooperation with the Swiss SLF institute. Environmental toxicology teaching includes environmental investigations in and

April 2019: The AT-307F course group photo in Van Mijenfjorden. Photo: Aleksey Shestov/UNIS.

around Longyearbyen, Svea and the Russian settlements Barentsburg and Pyramiden. The department has developed a study offer together with NTNU and the Technical University of Denmark in "Nordic Master - Cold Climate Engineering" where we this year received four very qualified master students for courses and master research work.

RESEARCH

The Arctic Technology Department conducted research in a wide field in 2019, within ice mechanics and offshore engineering, geotechnics, environmental chemistry and toxicology, and marine technology.

Ice mechanics and offshore engineering

The research group consisted of one full time professor and two adjunct professors, whereas one research associate and one postdoc were part of the group through external projects.

The group conducted fieldwork and data collection at various sites around Svalbard; Van Mijenfjorden (Sveabukta) and in the Barents Sea Opening, focusing on ice strength properties, ice drift patterns, drag forces and energy flux to drift ice, ice rubble structure, and iceberg studies. Field studies of internal waves and wave damping by land fast ice were performed together with a group at the University of Oslo (UiO), to develop a model of wave damping in the marginal ice zone of drift ice. The work was supported by the projects *Arctic Offshore and Coastal Engineering in changing Climate* (AOCEC, 2018-2020) of the IntPart programme *Dynamics of Floating Ice* (DOFI, 2018-2021) of the Petromaks2 programme, *Safety of Industrial Development and Transportation Routes in the Arctic* (SITRA, 2015–2019). Aleksey Marchenko is the leader for AOCEC and SITRA.

The AOCEC project supports the cooperation of UNIS in research and education with NTNU and UiO (Norway), Memorial University of Newfoundland, Dartmouth College and University Alaska Fairbanks, Lomonosov Moscow State University and Moscow Institute of Physics and Technology.

Fieldwork with visiting researchers from Canada, Russia and USA were performed in March 2019 on land fast ice in Svea. Focus was on the investigation of the rheology of sea ice subjected to vibrations, and collisional interaction of submerged ice blocks. Measurements of acoustic emission were performed in the tests. Vibrations were initiated by pulse action on floating fixed ends beams, and by vibrating plate standing on the ice. Indentation tests and uniaxial compression tests were performed on natural ice and on ice subjected to vibrations preliminary. Spectral analysis was used to determine natural frequency of vibrating beams and to calculate their elastic modulus.

Fieldwork onboard Polarsyssel focused on the investigation of morphology, strength and permeability of sea ice ridges drifting to the south-east of Hopen. Nataly Marchenko scanned the drift ice ridge and the iceberg. Original ice trackers were deployed on drift ice and small icebergs. The ice trackers are equipped with IMU and transmit their GPS coordinates and spectrum of the accelerations. Collected data were used for the investigation of 3D motion of the iceberg. Measurements of iceberg accelerations induced by wave actions are important for the estimation of iceberg loads on structures and for the iceberg management. Special focus of the onboard measurements was on the registration of internal waves due to the interaction of tidal currents with bottom topography. Semidiurnal changes of temperature and salinity were registered by CTD profiling. It was discovered that similar changes exist in the ocean heat flux calculated by the fluctuation analysis of sea current velocities and water temperature in the surface ocean layer. Temperature effects induced by internal waves may influence concrete foundations of offshore structures.

October 2019: The Arctic technology department perform laser scanning of the roads in Longyearbyen. Photo: Nataly Marchenko/UNIS.

In the UNIS cold laboratory we investigated deformations of sea ice and lake ice under cyclic changes of the room temperature, and effect of filling of ice cracks with water at the freezing point. The measurements were used to study thermally induced ice loads in the coastal zone of land fast ice, where tidal elevation of the water level influences formation of tidal cracks and regular floods. Similar laboratory investigations were performed with samples of saline and fresh frozen soils. This work, partially supported by the SITRA project, is a part of the PhD project of Artem Nesterov (St. Petersburg State Polytechnic University/UNIS). Laboratory works in the wave tank were focused on the investigation of soil permeability under cyclic changes of pressure gradient in the ground water, utilizing a specially designed pump and electronic switcher system. The experimental results will be used for the modelling of ground water migration in coastal zones.

Aleksey Marchenko was co-editor of the special issue "Hydrodynamics of sea ice" in the journal Applied Ocean Research, where 5 papers were published based on the results of work performed in the centre for research-based innovation SAMCoT (see separate chapter).

Nataly Marchenko continued activity from the MARPART project, with the follow-up project *Inter-organizational coordination of mass rescue operations in complex environments* (MAREC 2018-2020), where UNIS is the project responsible. The focus is on improvement of safety in the Arctic seas. Nataly developed the online Geographical Information System (GIS) MarEmAr – *Marine Emergencies in the Arctic.* It shows ship accidents on the map, explains how the situation developed and what conclusions were drawn. MarEmAr is created for preparedness and response improvement to be a teaching tools and a networking platform.

Another project is for Avinor, with continued investigation of deformations of the Longyearbyen airport runway and roads in the town. Based on high-resolution scanning, surface data from several years are compared and the locations of areas with large surface movements are identified. Identified changes of the runway, with bumps and surface movements, are inputs to the Avinor's maintenance planning.

Geotechnics

This research group consisted of one full time professor and one adjunct professor, and one postdoc. One of the main projects was the finalization of the *Norwegian Geo Test Site -Permafrost site* in Adventdalen (NGTS), https://www.ngi.no/Prosjekter/NGTS-Nasjonale-Geoforsoeksfelt), setting up online instrumentation in the

April 2019: Staff and students in the AT-211 course getting ready to perform fieldwork on an ice floe. Photo: Nataly Marchenko/UNIS.

site and organization and documentation of frozen soil data, stored soil samples, measurement series on thermal regimes, etc. for future use.

The RCN supported project *Monitoring of Arctic Infrastructures* (MONARC), focusing building survey and foundation levelling to observe settlements on building foundation in Pyramiden, Barentsburg, Svea and Longyearbyen was finalized. This project has given valuable insight into effects of warming climate on structures and foundations in Svalbard. Participants were Sintef, UNIS, Moscow State University, Trust Arcticugol (Barentsburg/Moscow) and SNSK.

The group works together with researchers from NMBU and has developed a research installation in Adventdalen with solar panels and radiation meters. The research focus spans from solar power production from regular and bi-facial panels, to the effect of environmental loads from wind, snow drift and accumulation, dust, etc. Preliminary results were presented at an international conference.

The Horizon 2020 project *Nunataryuk* (https://www.nunataryuk.org/), between NTNU, DTU and UNIS, designed a field test setup for piles in marine permafrost clay at the NGTS site east of UNIS. Pile tip loading on the clayey soil will run for two years to establish data for soil creep behaviour in the warming permafrost soil. Both PhD and master students are involved in this work.

Environmental chemistry and toxicology

The research group consisted of three adjunct professors and one PhD candidate. The group has participated in several projects, and has had activity in Longyearbyen, Ny-Ålesund and Barentsburg.

The Barentsburg chemistry laboratory has served as fieldwork platform for research and education for the UNIS course AT-324/824 "Techniques for the Detection of Organo-Chemical Pollutants in the Arctic Environment", led by adjunct professor Roland Kallenborn (NMBU/UNIS). 12 students and 3 teachers conducted laboratory and fieldwork in the Grønfjorden vicinity. Until today, more than 45 master and PhD students have benefited from the open and constructive academic collaboration with our Russian colleagues in Barentsburg, an activity that will be continued in the future.

In the project *Reducing the impact of fluorinated compounds on the environment and human health* all samples collected are prepared and quantified. A comprehensive manuscript is currently under preparation for publication in a peer-reviewed journal.

As a part of an AFG collaboration with University of Venice, Alice Callegaro conducted fieldwork and soil sampling in Ny-Ålesund in August/September 2019. She collected soil samples from the active layer of the permafrost (surface sample) from 6 different location in and around Ny-Ålesund. The samples were subsequently divided for separate quantitative analysis at UNIS and at the University of Venice. Currently, the analysis for indicator persistent organic pollutants (POPs) is in progress in Venice. At UNIS, the remaining samples will be quantified for perfluoroalkyl substances (PFASs) and other emerging arctic contaminants during autumn 2020.

The Arctic molecular ecotoxicology activities, led by adjunct professor Helena Reinardy, have focused on completing collaborative projects with the Arctic University of Norway, Akvaplan-niva, and Nord University. We are looking at impacts of oil pollution, climate change, and ocean acidification on key aspects of Arctic ecosystems including polar cod and Arctic zooplankton. Using the excellent molecular laboratory facilities at UNIS, in particular the qPCR instruments, we are looking at gene pathways and individual gene responses in a variety of species and tissues. We are also developing a focus on genetic and epigenetic effects in order to understand how vulnerable Arctic organisms are to pollution and changing environmental conditions. The work has led to two journal papers.

PhD student Tatiana Drotikova completed extensive fieldwork in order to determine potential sources of PAHs and nitro- and oxy-PAHs in Longyearbyen. Large volume ambient air samples were collected in different locations including at the SvalSat station in order to estimate long-range atmospheric transport input into the total detected level of the PAH derivatives. Analyses of the air samples were performed at NMBU and INERIS (Paris, France). In September 2019, Drotikova was awarded the 2nd place best student platform presentation "Pattern and distribution profile of PAHs and transformation products from an Arctic point source" at the ISPAC conference in Sweden.

In a RCN financed project, exposure levels and effects of per- and polyfluorinated substances (PFAS) in Svalbard glaucous gulls have been investigated and compared with levels in glaucous gulls in Greenland. Adjunct professor Bjørn Munro Jenssen (NTNU/UNIS), PhD candidate Åse-Karen Mortensen (NTNU/UNIS) and one MSc student has been involved in this project. The RCN-financed project *Reducing the impact of fluorinated compounds on the environment and human health,* PhD candidate Håkon Langberg (NTNU/UNIS) investigated levels and effects of PFAS originating from the use of aqueous fire-fighting foams (AFFF) at Svalbard airport. This project is a collaboration between NGI, NTNU, NMBU and UNIS. Furthermore, during the field course in AT-330, sampling of reindeer faeces as bioindicators of local and long-range pollution of toxic elements was continued. In the RCN project TerrACE, MSc student, Connor McKnight (NTNU/UNIS) investigated biotic mercury accumulation in an Arctic coastal lagoon at Prins Karls Forland.

Three master students supervised by professor Øyvind Mikkelsen and other co-supervisors had guest master's agreements or longer stays at UNIS connected to their master thesis projects in 2019. Torstein Bye collected snow samples in Adventdalen, Sassendalen and Brøggerdalen for his project on capture mechanism of mercury in Arctic snow, Oda Siebke Løge studied use of digestive gland explant cultures from blue mussels *(Mytilus edulis)* to assess biomarker effects of single and co-exposure of environmental contaminants, and Ida Byrkjeland collected micro and macro plastic in Longyearbyen, Ny-Ålesund, and Isfjord Radio for studies of degradation mechanisms as well as absorption mechanisms of organic pollutants. Additionally, Professor Øyvind Mikkelsen is coordinating the activity *Long-time monitoring and Observations and Studies of biogeochemical interactions in ARTIC soil and water systems* (LOSARCTIC 2019 – 2029).

Marine technology

This group consisted of two adjunct professors in 2019. The group activity is closely linked to the *Centre of Excellence for Autonomous Marine Operations and Systems* (AMOS) at NTNU, and working with autonomous vehicles underwater, on the surface and in the air. In June 2019 NTNU, the Arctic University of Norway and UNIS organized an archaeological survey to Amsterdamøya and Danskøya to search for Dutch whaling vessel wrecks from the 17th century. The survey was supported by the Governor of Svalbard through the Svalbard Environmental Protection Fund. Large areas were mapped using AUVs and side scan sonar supported by an USV for precise navigation without being able to locate the sunken vessels.

GRADUATES 2019

MASTER'S DEGREE:

RUNA SIMONSEN BLIX
Sikkerhet i industrielt arbeidsliv i Arktis. *(NTNU and UNIS).*

TORSTEIN BYE
Capture mechanisms of mercury in snow and ice in the Arctic. *(NTNU and UNIS).*

IDUN EIKEN
An experimental study of thermal properties and the influence on the ground thermal regime in permafrost soil. *(NTNU and UNIS).*

LISE ENDRESEN
Sikkerhet i industrielt arbeidsliv i Arktis. *(NTNU and UNIS).*

JØRGEN HOLST
Læring av øvelser. Hvordan kan øvelser lede til læring i beredskapsorganisasjoner? *(The Arctic University of Norway and UNIS).*

FEDOR IUROV
The problem of the stability of linear technogenic systems in the permafrost zone: regional features. *(Moscow State University and UNIS).*

PEDER SVANE
Resilient teams and cooperation in extreme conditions. *(The Arctic University of Norway and UNIS).*

SAMCOT

BY SVEINUNG LØSET, CENTRE DIRECTOR (NTNU AND UNIS).

A muscle in the development of Arctic technology at UNIS has been the Centre for research-based innovation (SFI) Sustainable Arctic Marine and Coastal Technology (SAMCoT).

The vision of SAMCoT was, from the very beginning in 2011, to be a leading international centre for the development of robust technology needed by industry operating in the Arctic. For this purpose, SAMCoT's goal was to perform research that would aid the industry in the environmentally friendly development of the Arctic, where unique challenges are presented by ice, frozen soil/permafrost and coastal erosion. In pursuing that goal and in achieving success, SAMCoT is making the host institution, The Norwegian University of Science and Technology (NTNU), a leading international centre in Arctic science and engineering. The Arctic Technology (AT) department and the Logistics unit at UNIS have contributed strongly to this development and success. There are several ways of transferring knowledge to the industry. At SAMCoT, we believe that this can be best achieved through strong collaboration between academia and industry; e.g. MSc and PhD students bringing their knowledge directly into industry through employment or co-work on specific and relevant tasks.

The consortium has comprised nine research partners, 12 industry partners and two public partners. At the closing of SAMCoT, the Chair of the Scientific Advisory Committee, Professor Erland Schulson said: "The overall performance is very good. In addition to the numerous conventional publications (450 international publications), SAMCoT researchers have made significant contributions to ISO standards, specifically to the new 2nd edition of ISO 19906, Arctic Offshore Structures, and to the first edition of ISO 35104, Arctic Operations-Ice Management".

A major delivery of SAMCoT is the PhD and MSc students that have gotten the opportunity to attend our schools. These schools range from desk studies, seminars, laboratory studies to full scale field surveys, including icebreakers. The field surveys range from Pole to Pole with unique data collection and training. From an educational perspective we know that after taking part in such field trips, the students come back with a more realistic view of the Arctic and a better understanding of their research topics. In other words, they become grown-ups.

For an SFI both impact and innovation are important. The AT department at UNIS has contributed to 45 innovation ideas that are registered in SAMCoT. From these ideas three major commercial inventions have been made:

- The spin-off company ArcISo;
- A numerical code for assessing ice-induced vibrations of structures;
- A unique Thermo-Hydro-Mechanical constitutive model of frozen soil behaviour.

Professor Sveinung Løset. Photo: Aleksey Shestov/UNIS.

The trawler «Northguider» shipwrecked in Hinlopenstretet in late December 2018. Photo: The Governor of Svalbard.

ArcISo's impact is easily visible and manifests itself in several projects that were successfully executed in 2019. An example of benefit for the local community in Longyearbyen and the Governor is the story of the trawler "Northguider", which stranded in Hinlopenstretet on 28 December 2018. The accident happened in a very vulnerable area which is sometimes surrounded by drift ice. The Coastal Administration consulted ArcISo to assess the risk of having "Northguider" pushed by sea ice to deeper waters and to advise whether a salvage operation could wait until summer when it would be much easier, safer and more economical to operate. Here, the ArcISo simulator SAMS has been of great use. The ice conditions were thoroughly reviewed, and tens of scenarios were simulated and analysed. This has enriched the situational awareness for all stakeholders enabling decision making; something the Coastal Administration and the Governor were very grateful for.

More on www.ntnu.edu/samcot

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September 2019: Longyearbyen seen from Platåberget. Photo: Emil Söderlund/UNIS.

September 2019: Student kayakers encountered a group of belugas that came into Adventfjorden. Photo: Emil Söderlund/UNIS.

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ARCTIC GEOLOGY

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Kolari	Kari	VTT Technical Research Centre of Finland
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