UNIS

The University Centre in Svalbard

ANNUAL REPORT 2021

Front page | **April 2021:** Drilling for groundwater at Von Postbreen, as part of the CLIMAGAS project. Photo: Andy Hodson/UNIS.

Editor | Eva Therese Jenssen.

April 2021: A curious Svalbard reindeer *(Rangifer tarandus platyrhynchus)*. Photo: Sil Schuuring/UNIS.

FROM THE DIRECTOR

UNIS takes full advantage of the unique location in the high Arctic. We document the effects of the rapid climate warming. In Longyearbyen we have experienced a dramatic increase in the annual average temperature of 5 degrees Celsius in 30 years. This information is critical to predict regional climate scenarios. Due to field intensive education and research activities, students and staff develop adaptive skills to tackle climate driven natural hazards. The local challenges are global challenges, and thus these skills are transferable to anywhere.

UNIS offers an international study environment, all teaching is given in English, with students from more than twenty countries every semester. The practical skills developed during field work and living in the high Arctic are sought-after by future employers, not only by polar research institutions. Norwegian students may consider UNIS to be an excellent alternative to an international student exchange. *Samskipnaden's* brand new student housing, inaugurated in autumn 2021, has the capacity to accommodate all UNIS' students. The architecture and construction are special and future-oriented in several ways, with high energy efficiency. Part of the year it is self-supplied by electricity from solar cell panels on the roof.

The number of applicants for UNIS courses have steadily increased during the pandemic, but due to Covid-19-precautions, the student production in 2021 was 75% of a normal year. Covid-19 has forced us to speed up our efforts to be able to offer teaching digitally. We went from 100 percent physical teaching pre-Covid-19 to 100 percent digital teaching immediately after the pandemic outbreak. We have invested in audio-video systems to support high-quality hybrid lectures. A high proportion of guest lecturers contributed with their teaching digitally in 2021. Most business meetings are conducted digitally. The "disadvantage" of our remote location at 78 degrees has been drastically reduced, our organisation is more efficient, greener with less air travel and allows for more quality time for our families living in Longyearbyen.

Research-wise we have had a great advantage of living in the Arctic during the pandemic. Most of the planned field campaigns and research expeditions were executed in 2021. However, the work situation with home offices has of course been demanding for many, and limited mobility

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

due to travel-restrictions has prevented access to specialized laboratories outside Svalbard. Nevertheless, the science production has been high.

In 2021 the Norwegian government decided to terminate the coal power plant in 2023 and change to diesel as the primary energy source. There is an expressed aim to gradually transform into as much renewable energy as possible. Presently, renewable energy solutions for the high-Arctic does not exist. Thus, there is a high innovation potential. UNIS is currently engaging in consortia to develop a research and innovation platform for energy companies to use Longyearbyen as a test site to certify energy solutions for a global market.

UNIS takes full advantage of living in a "climate laboratory". In 2021 we kicked off two interdisciplinary research activities of high local and global relevance: The *PermaMeteoCommunity* project - *Developing a permafrost and meteorological climate change response system to build resilience in Arctic communities.* The aim is to develop a new concept for combined monitoring of permafrost and weather, and if successful, it has the potential to become a valuable export article. The other one is *ARCT-RISK - Risk governance of climate-related systemic risk in the Arctic*, where the primary goal is to develop knowledge and proper tools to deal with effects of climate change on society's ability to protect citizens and to maintain critical infrastructure and functions.

Finally, I would like to thank all our students, staff, and our collaboration partners, who enabled us to deliver so much in 2021 despite the Covid-19 constraints. Our goal of finding sustainable solutions to save our planet continues unabated.

Jøran Moen
Managing director

EXCERPT FROM THE BOARD OF DIRECTORS' REPORT 2021

The University Centre in Svalbard AS (UNIS) is a state-owned limited corporation administered by the Ministry of Education and Research. The company'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 the 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.

In 2021, the University of South-Eastern Norway (USN) was included in the Cooperation Agreement of 2011 concerning research and education in Svalbard. A total of nine universities on the Norwegian mainland are now covered by the agreement.

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

COVID-19

A healthcare worker with responsibility for infection control was employed in a full-time position during the year to take care of infection control in the day-to-day operations. Student admissions for the spring semester in 2021 were reduced because of the unpredictability related to entering Svalbard, the capacity to handle local outbreaks and to safeguard students and projects in the field.

At Easter time, it became necessary to reserve capacity at the Arctic Student Welfare Organisation's student housing to isolate Covid-19 patients in the event of an outbreak. However, much of this capacity had to be redistributed to house the students who needed to be evacuated from Nybyen from Easter until mid-June because of the risk of avalanches.

A high proportion of guest lecturers in 2021 provided their teaching as digital lectures.

ECONOMY

Funds for operation and investments at UNIS are appropriated in the budget of the Ministry of Education and Research. In 2021, the appropriations from the Ministry totalled NOK 36,322,000, but this was based on the factor that UNIS would make a profit of NOK 110,700,000 from the sale of dwellings to the Norwegian Directorate of Public Construction and Property (Statsbygg). Furthermore, UNIS received an additional allocation of NOK 3,710,000 in the revised national budget to cover capital costs associated with leasing the dwellings back from Statsbygg and leasing learning areas in the Arctic Student Welfare Organisation's new student housing building at Elvesletta.

UNIS received an allocation of NOK 1 million from the Ministry of Trade, Industry and Fisheries earmarked the Arctic Safety Centre to contribute to enhanced competence about sustainability and safe activity in the Arctic.

Of the total allocation registered as income, NOK 8,127,396 was spent on investments in equipment. Furthermore, investments in technical-administrative and scientific infrastructure totalling NOK 7,108,769, of which NOK 2,310,199 capitalized in the balance sheet. UNIS will receive and capitalize the remaining amount, NOK 4,798,570, in spring 2022.

Income beyond the allocations from the Ministry of Education and Research and the Ministry of Trade, Industry and Fisheries comprises NOK 60,397,697, of which NOK 40,185,332 is related to external project income for research and the remaining NOK 20,212,365 is income from rentals and other income. After capitalization of purchased infrastructure, the accounts for 2021 show a surplus of NOK 7,041,469.

Two years with good financial wiggle room has enabled UNIS to catch up on a large backlog of infrastructure of both a technical-administrative and academic nature. An upgrade of the UNIS website has also been initiated. The purpose of this is to modernise the design of the website and make it more user-friendly for students and other users.

Furniture and AV equipment totalling just under NOK 2 million has been ordered for the areas UNIS is leasing in the student welfare association's new housing block at Elvesletta. The largest area (net floor area 216 m^2) is a student learning area, while the other area (net floor area 80 m^2) will be used for projects of relevance for the community in Longyearbyen.

The financial wiggle room created by freed up funds in both 2020 and 2021 has been utilised actively to contribute to a future-oriented UNIS, which is now better equipped to manage a new normal, in a safe and secure way, with high quality digitalisation of education, research and administrative services. See the detailed accounts and balance sheet on page 10-11.

BOARD OF DIRECTORS AND ANNUAL GENERAL MEETING

In 2021, the Board of Directors held four board meetings and one item was considered via circulation by e-mail. All the board meetings were held via Microsoft Teams owing to the Covid-19 situation. A total of 65 items were discussed officially. The Annual General Meeting was held in Oslo on 1 June 2021.

EDUCATION AND STUDENT STATISTICS

In 2021, 482 students spent shorter or longer periods at UNIS, including both course students and guest students.

The Covid-19 restrictions introduced in 2020 were still partially in force in 2021, and consequently affected activity this year too. In the spring semester, most of the master's and PhD courses were cancelled, while the maximum number of students in each course was set at 80% of normal capacity. However, in the autumn semester, no restrictions were placed on courses or the number of students.

A total of 60% of the students came from programmes of study at Norwegian universities, while the proportion of Norwegian citizens was 40%. This represents an increase compared to the years before the pandemic. The discrepancy between Norwegian citizens and students from Norwegian universities can be attributed to the fact that foreign nationals are admitted to ordinary programmes of study at Norwegian universities.

The Norwegian university that sends the most students to UNIS is UiT, The Arctic University of Norway, while the Norwegian University of Science and Technology (NTNU) has had the highest relative increase. Students from 32 countries were represented at UNIS in 2021. As mentioned, the largest student group came from Norway (60%), followed by students from Germany (18%) and the Netherlands (10 %).

A total of 162 student-labour years were produced at UNIS in 2021, which is a nice increase from 97 student-labour years in 2020, but still somewhat less than the target for UNIS of 220 student-labour years.

The results from the final assessment of the courses were above average, with B as the average grade. The failure rate was low (1%).

UNIS had 29 PhD candidates in 2021, and seven public defences were held.

RESEARCH AND ACADEMIC INITIATIVES – EXTERNAL FUNDING

In line with UNIS's strategy, the institution is developing goals and organisational structures to strengthen research. UNIS has developed and implemented new regulations for R&D projects, which were adopted by the Director on 6 April, and appointed a head of research in a part-time (50%) position from 1 October 2021. The regulations combined with active research management will provide greater and clearer focus on research through research initiatives being gathered, better coordinated and followed up. Moreover, the processes will become clearer, the legal basis will be safeguarded, and the total costs can be budgeted.

During 2021, UNIS received funding for several small and large research projects. The Department of Arctic Biology (AB) is the largest partner in a new project funded by the Research Council of Norway (RCN), led by the University of Bergen (UiB), *(Terra - Thawing permafrost in the High Arctic: Understanding climate, herbivore and belowground feedbacks)*, which will study the climate, herbivores and the belowground processes that occur when the permafrost thaws. AB has also entered as a third party under SIOS on the EU/H2020-funded project ENVRI FAIR, which aims to make collected data more "FAIR" *(Findable, Accessible, Interoperable og Reusable)*.

At the Department of Arctic Geology (AG), UNIS's first internally financed *strategic pilot project* (SPP) commenced. Called *PermaMeteoCommunity*, the project will develop a permafrost and meteorological climate change response system for Arctic communities. AG has received funding from RCN to further develop the Svalbox project which, like ENVRI FAIR, deals with making existing data from Svalbard accessible. However, this project has special focus on geoscientific data in the Svalbox portal.

By appointing a new associate professor in remote sensing, the Department of Arctic Geophysics (AGF) has formally been transferred several duties from the Meteorological Institute in the ESA-funded *Climate Change Initiative.* During 2021, UNIS appointed the final externally funded position (a postdoctoral fellow) at the *Birkeland Centre for Space Science*, which is a Centre of Excellence, as well as self-funded PhD position.

The Department of Arctic Technology (AT) has started an internal initiative related to renewable energy. Within the course of a year, a professor post in Arctic energy and two PhD positions, focusing on wind and solar energy in the Arctic, respectively, have been filled. These appointments, combined with investments in equipment of around NOK 1 million, have led to the development of expertise and a research community that can generate further project activity and funding in the years to come.

Of other major and important projects in which UNIS is involved, we wish to mention the following: AB has a key role in the marine sampling in Svalbard in the EU/H2020 project FACE IT (*The future of Arctic coastal ecosystems - Identifying transitions in fjord systems and adjacent coastal areas*). AB and AGF are both heavily involved in The Nansen Legacy, and work extensively on tasks within marine biology, data management and oceanography. AG and AGF are well underway with *iEarth* (*Centre for Integrated Earth System Education*), a Centre for Excellence in Education led by UiB, which also has a significant research component. *At ARCT-RISK (Risk governance, early warning and climate change adaptation in the Arctic)*, an NTNU-led project on risk management

of climate-driven natural hazards, UNIS has during 2021 appointed a self-funded PhD position, a postdoctoral fellow and a researcher with project funding.

The combined income from the externally funded projects in 2021 was approx. NOK 40,200,000.

Finally, we would like to mention two other major initiatives: SIOS *(Svalbard Integrated Arctic Earth Observing System)*, which has been organised as a subsidiary of UNIS through SIOS Svalbard AS since 2017, has as its main task to coordinate and further develop an international research infrastructure to explore regional effects of climate change. The total turnover of SIOS Svalbard AS in 2021 was NOK 33,100,000. *Arctic Safety Centre (ASC)* received an allocation of NOK 1 million from the Ministry of Trade and Industry for 2021 to contribute to increased competence about sustainable and safe activity in the Arctic. The funds have been used on concept development for an ASC knowledge centre, further development of practical safety courses for the business community and dissemination of expertise in Arctic safety through digital initiatives such as webinars.

Even though the past year has also been influenced by Covid-19, this has not had as much consequence as in 2020. Field campaigns and research cruises have both been affected, postponed or cancelled in 2021. However, UNIS has certainly benefitted from proximity to the field and a generally low level of infection, so the situation has probably been better here than in many other parts of the country.

STAFF

As of 31 December 2021, the faculty at UNIS comprised of 13 professors, 12 associate professors, five researchers, 10 postdoctoral fellows, 20 PhD candidates, one research assistant and 50 staff with adjunct professor/associate professor attachments. Furthermore, there were 44 technical and administrative staff.

Women accounted for 40% of the faculty positions and 45% of the technical and administrative positions (41% of the staff). Five of the 11 members of the Board of Directors were women, as well as two of the eight members of the management group. The proportion of women in the other internal committees ranged between 33% and 67%.

The fact that Svalbard is not a life cycle community is reflected in the population and the employees at UNIS. As the higher education sector is an international sector, it is natural that UNIS has a high proportion of international staff (approx. 46%). In 2021, UNIS started offering Norwegian courses to its employees, which promotes an inclusive workplace and local environment, as well as career development.

HEALTH, SAFETY, AND ENVIRONMENT

Absence due to illness at UNIS in 2021 was 1.8%. All employees at UNIS are offered a work-related medical examination as part of our collaboration with the occupational health service (OHS). OHS reports that more employees than previously have contacted them for help with both physical and psychosocial challenges. Most of these challenges are related to the effects of Covid-19 and the need to work from home.

The extent to which the Covid-19 situation had a negative effect on the working environment varied greatly for the individual employee. Factors such as nationality, local network, duties and responsibilities, the need to travel and need for supervision have been important. Physical presence at work has been possible, and necessary, for most employees in the technical-administrative departments. However, working from home has been the norm for many academic staff, and the lack of being physically together with colleagues has obviously been demanding. UNIS has attempted to follow up each individual employee with special needs throughout the year to ensure that everyone gets through the pandemic without harmful effects.

In late autumn 2021, UNIS conducted a survey among students and staff as part of an evaluation of how the institution has handled the pandemic. This provided several learning points.

Personal safety during fieldwork is a high priority at UNIS. Students and staff require sufficient competence to be able to perform their own fieldwork and take care of themselves and others under demanding conditions. Quality assurance of all aspects of the fieldwork starts early in the planning phase and is followed up throughout the duration of the fieldwork. Safety factors during fieldwork are evaluated systematically and experiences are incorporated into planning.

In all, 125 safety courses and seminars were held in 2021. These were attended by a total of 867 people. The learning objectives and content of safety courses are a result of risk analyses and subsequent operational procedures constantly being developed in line with the learning and experiences we acquire through the fieldwork.

The High Arctic natural environment has always been demanding to live and work in. However, climate change is leading to extensive and rapid changes that call for rapid adaptation and new operational procedures. In many contexts, basing activity in the natural environment on historical knowledge and experience is insufficient.

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's activity in the field. During 2021, UNIS further developed the collaboration concerning the collection of the snow data used to prepare local avalanche forecasts for the Longyeardalen and Nordenskiöld Land.

UNIS's 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. For all fieldwork, the possible negative environmental impact is evaluated in the same way as personal safety.

UNIS registers all field activity, which provides us with detailed and valuable data of how many people we have had in the field, in which area, for how long and the means of transport used. The type of fieldwork, machinery, instruments, and any use of harmful substances is also registered.

UNIS will use the basic data we have collected over many years to describe the actual, negative environmental footprint of our activity in as much detail as possible. Furthermore, we aim to be able to calculate the negative footprint of all fieldwork in the form of CO2 emissions and physical impact. This will provide us with another tool to be able to minimise our negative footprint.

In 2021, UNIS started work on establishing a green strategy. The initial goal is to develop clear formulations of goals and targets of how to map and then reduce this footprint. We are working actively and purposefully at both the strategic and operational level to minimise our footprint.

UNIS is unaware of any activity that we had during 2021 that has generated point source emissions of harmful substances or that has otherwise resulted in a specific negative impact, beyond what normal operations require.

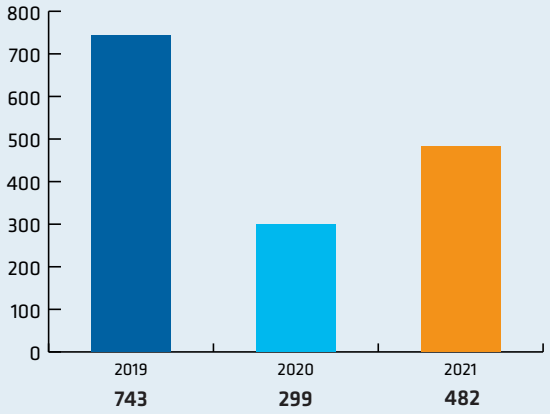
LONGYEARBYEN, 16 MARCH 2022:

Chair of the Board Morten Hald (UiT - The Arctic University of Norway); Deputy Chair Nina Frisak; board members Robert Bjerknes (University of Bergen); Brit Lisa Skjelkvåle (University of Oslo); Øyvind W. Gregersen (NTNU); Siri Kalvig; Stein-Ove S. Johannessen (Longyearbyen Community Council); Marius O. Jonassen, Elise Strømseng and Nina Kristine Eriksen (staff representatives); Sebastian D. Junker Andersen (student representative) and Jøran Moen (director).

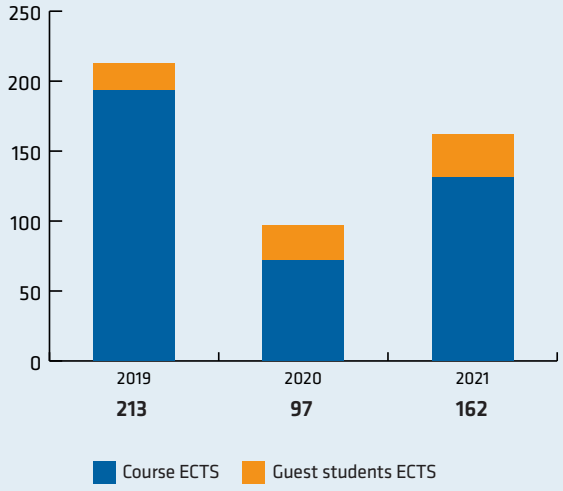
October 2021: Samskipnaden's (student welfare association) new housing block at Elvesletta in the centre of Longyearbyen where UNIS leases student learning facilities. Photo: Ragnhild Utne/Samskipnaden.

STATISTICS

TOTAL NUMBER OF STUDENTS

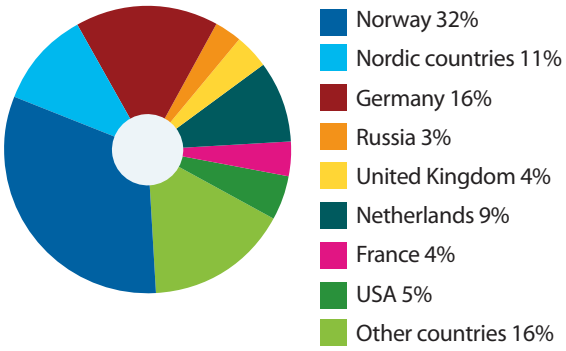


PRODUCTION IN STUDENT-LABOUR YEARS (1 YEAR = 60 ECTS CREDITS)

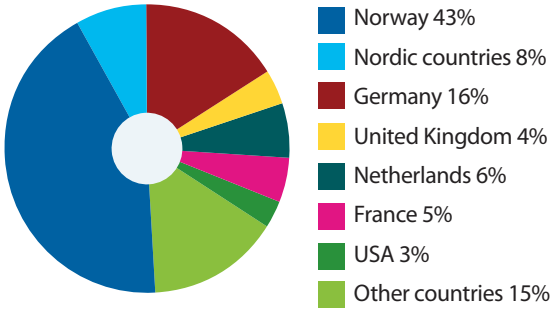


Note: UNIS registers ECTS by 1) course production and 2) guest students attendance

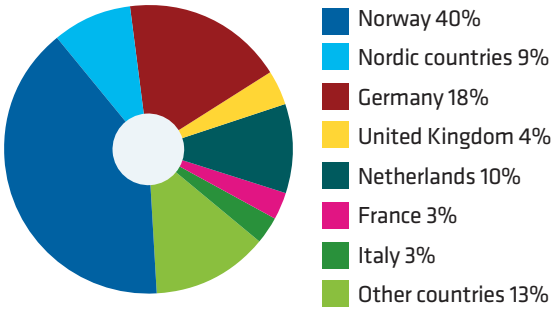
STUDENT NATIONALITY 2019



STUDENT NATIONALITY 2020



STUDENT NATIONALITY 2021



PROFIT AND LOSS ACCOUNT 2021

GROUP*			University Centre in Svalbard AS	
2021	2020		2021	2020
NOK	**NOK**	**OPERATING INCOME**	**NOK**	**NOK**
40 032 000	142 463 000	Operating grant from the Ministry	40 032 000	142 463 000
15 768 928	14 045 763	Other grants	1 000 000	1 609 230
0	0	Appropriation for investments	0	0
55 800 928	**156 508 763**	**Operating grant from the Ministry**	**41 032 000**	**144 072 230**
58 515 241	56 867 197	External project income	40 185 332	38 110 328
127 942 605	11 942 165	Other incomes	130 742 605	14 742 165
242 258 774	**225 318 125**	**Gross operating income**	**211 959 937**	**196 924 723**
50 189 804	50 452 452	Direct project expenses	31 957 756	31 736 057
192 068 970	**174 865 673**	**Net operating income**	**180 002 181**	**165 188 666**
		OPERATING EXPENSES		
91 859 570	78 816 689	Salary and related expenses	86 403 054	73 475 945
8 963 325	1 721 805	Fieldwork and cruise	8 963 325	1 721 805
38 434 605	39 487 003	Buildings	38 434 605	39 487 003
41 568 288	30 695 092	Other operating expenses	34 934 549	26 491 701
4 593 394	1 848 000	Depreciation	4 593 394	1 848 000
185 419 182	**152 568 589**	**Sum operating expenses**	**173 328 927**	**143 024 454**
6 649 788	**22 297 084**	**OPERATING SURPLUS**	**6 673 254**	**22 164 212**
		FINANCIAL INCOME AND EXPENSES		
650 602	987 770	Financial income	622 955	970 716
274 984	707 215	Financial expenses	254 740	542 025
375 618	**280 555**	**Net financial items**	**368 215**	**428 691**
7 025 406	**22 577 639**	**Net profit for the year**	**7 041 469**	**22 592 903**
		Information about appropriations to:		
		Transferred from/to other equity	7 041 469	22 592 903
		Sum transfers	**7 041 469**	**22 592 903**

* The UNIS group consists of the University Centre in Svalbard AS and the subsidiary companies UNIS CO2 lab and Svalbard Integrated Arctic Earth Observing System (SIOS).

BALANCE SHEET 31.12.2021

GROUP*			University Centre in Svalbard AS	
2021	2020		2021	2020
NOK	**NOK**	**FIXED ASSETS**	**NOK**	**NOK**
		Fixed assets (tangible)		
0	27 405 208	Buildings	0	27 405 208
14 574 053	15 921 799	Scientific equipment and infrastructure	14 574 053	15 921 799
14 574 053	43 327 007	Sum tangible fixed assets	14 574 053	43 327 007
		Fixed assets (financial)		
0	0	Investments in subsidiary company	175 000	175 000
2 780 000	0	Long-term receivables	2 780 000	0
2 780 000	0	Sum financial fixed assets	2 955 000	175 000
17 354 053	**43 327 007**	**Sum fixed assets**	**17 529 053**	**43 502 007**
		CURRENT ASSETS		
16 888 346	15 414 716	Accounts receivable	7 209 254	4 822 723
21 734 912	12 362 790	Other short-term receivables	21 738 242	11 436 282
90 024 302	78 520 012	Cash and bank deposits	81 938 173	68 354 526
128 647 560	**106 297 518**	**Sum current assets**	**110 885 669**	**84 613 531**
146 001 614	**149 624 526**	**SUM ASSETS**	**128 414 722**	**128 115 538**
		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		
58 026 421	51 001 014	Other equity	58 182 211	51 140 742
58 026 421	51 001 014	Sum retained equity	58 182 211	51 140 742
60 080 446	**53 055 039**	**Sum equity**	**60 236 236**	**53 194 767**
		LIABILITIES		
		Other long-term liabilities		
0	10 809 796	Housing loan	0	10 809 796
0	10 809 796	Sum other long-term liabilities	0	10 809 796
		Short-term liabilities		
35 853 639	27 643 679	Accounts payable	24 886 716	18 031 642
3 736 458	2 945 701	Public fees and duties	3 619 050	2 834 543
46 331 071	55 170 311	Other short-term liabilities	39 672 721	43 244 791
85 921 168	**85 759 691**	**Sum short-term liabilities**	**68 178 487**	**64 110 976**
85 921 168	**96 569 487**	**Sum liabilities**	**68 178 487**	**74 920 772**
146 001 614	**149 624 526**	**SUM EQUITY AND LIABILITIES**	**128 414 722**	**128 115 538**

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

ARCTIC BIOLOGY

May 2021: PhD candidates Rebecca Duncan and Vanessa Pitusi doing fieldwork in Van Mijenfjorden. Photo: Maria Philippa Rossi/UNIS.

BY STEVE COULSON, 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 2021 the AB department consisted of four professors, three associate professors, seven PhD students, one postdoc, a researcher, a study coordinator, two engineers and nine adjunct professors.

EDUCATION

The course portfolio during spring 2021 was severely restricted due to Covid-19 and the cancellation of many spring semester graduate courses. Nonetheless, the bachelor courses and one master/PhD course were delivered during spring although with adjustments for digital teaching and examinations following the Covid-19 lockdowns. Many teaching sessions were hybrid, yet thanks to active collaboration between staff and students the courses were successfully delivered.

Our educational aim is to be the primary study site for learning high Arctic biology through genuine experience. Education at AB is research-based both in knowledge content and how we teach. Knowledge and skills are best conferred through student centred active learning and authentic research settings. Active involvement creates more motivated students and aids deeper learning. The educational development in the AB department is to a large extent linked to the Centre for Excellence in Education *bioCEED* and AB is collaborating with a second centre, *iEarth* also active at UNIS.

Our focus on educational development has also led to more research on education within the department. The goal of the inter-departmental and cross-disciplinary project *FieldPass* is to develop and research alternative forms of teaching and assessment suitable for field and laboratory related learning. Digital certification and reflection tools have been developed and tested in 2021 and the results shared at national conferences/workshops, at an institutional level, as well as through our FieldPass homepage (https://research.unis.no/fieldpass/). The Covid-19 situation made

August 2021: AB-201 students on fieldwork in Skansbukta, Billefjorden. Photo: Tina Dahl/UNIS.

the project develop alternative methods for testing tools for e.g., certification. Certification tools developed and first tested at UNIS are now being used and further developed in collaboration with UiB and UiO, and a multi-pronged dissemination plan (presentations, manuscript) is underway. Digital tools (such Virtual Field Guides) were tested. In cooperation with bioCEED, the Field Guides have been added to the departmental online learning platform Learning Arctic Biology (https://360.learningarcticbiology.info/).

The AB initiative *Bjørndalen Integrated Gradients* (BIG) includes both educational and research approaches, including research topics such as field education and has been achieved partly through funding from Thon to support the development of a Field Laboratory. In 2021, BIG provided a research arena for students admitted to the practical course AB-207 Research Project in Arctic Biology (15 ECTS) as well as for research internship students working at the site during summer 2021. BIG efficiently links field activities on different courses across seasons and is working towards gathering an expanding dataset for use in both teaching and research.

RESEARCH

The overall aim of the AB department is to remain a leading institution in high Arctic biological research using 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 was one of the departments' major activities during 2021.

In the EU funded project *FACE-IT* we mapped the inner part of Billefjorden, identifying a glacier station in front at Nordenskiöldbreen, one 'freshwater' station in Petuniabukta, and an additional station more affected by Atlantic water. A PhD student studied spatial differences at the three stations throughout the summer using UNIS' new autonomous surface vehicle (USV) which enables safe remote control and sampling. The sampling regime included CTD, turbidity, PAR measurements and an echosounder. Data gathered were validated with remote drop cameras and baited video rigs. The establishment of macroalgae will be one of the principal drivers for changes in benthic and fish communities. The study showed that the macroalgae established relatively early

after glacial retreat and that the increased turbidity close to glaciers had relatively little effect on establishment. Moreover, the study showed large spatial differences in plant coverage of kelp, with the lowest distribution of macroalgae in habitats affected by freshwater input. The kelp communities had a depth distribution down to >30 m, deeper than expected based on the light climate in such habitat.

The BIG project expanded in 2021 adding a dedicated meteorological station with real-time data delivery. BIG is an ecosystem 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.

Ongoing BIG activities include collection of invertebrates on a weekly basis and automated monitoring of plant phenology and plant-pollinator interactions with time-lapse cameras. This data collection is part of a larger circumpolar network aiming at using state-of-the-art machine learning and computer vision methods to study the role of climate in plant-pollinator interaction. For example, *Diptera* collections from BIG and the time lapse camera flowering images are being currently analysed as part of master's project and compared with data from a similar monitoring programme in Greenland.

The monitoring of arrival and breeding phenology of common eider (*Somateria mollissima*) have been added to the BIG monitoring program. The monitoring of eiders was started in 2015 and is now in its sixth year. Of note is that the arrival of eiders in Adventfjorden is apparently influenced by the large-scale climate system, the Arctic Oscillation, while, in contrast, the commencement of breeding is determined by local snow conditions. 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 by 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 2021, the Bjørndalen population increased from 21 animals in March to 101 in July. Reindeer are avoiding areas with deep snow and ice layers in winter. As spring and summer come, emergent new high-quality forage influences the reindeer's habitat choice in Bjørndalen.

Permafrost in Arctic regions is under severe threat as a consequence of climate change. Vegetation, and especially mosses, which play an important role in insulating soils, is expected to significantly change with climate warming, from moss types to vascular plant-dominated vegetation forms. Measurements of the active layer depth and accompanying abiotic parameters at the long-term

March 2021: PhD candidates Robynne Nowicki and Cheshtaa Chitkara working on the sea ice, retrieving a water sampling bottle from an ice hole, during a Nansen Legacy cruise. Photo: Andreas Wolden/Institute of Marine Research.

June 2021: Associate Professor Anna Vader trawls for plankton and microplastics in the surface water of Hinlopenstretet. Photo: Janne Søreide/UNIS.

monitoring sites in BIG and in Adventdalen continued. New sites were established ranging from moss and *Dryas octopetala*-dominated tundra to polygons in Adventdalen. Spatial grids with contrasting vegetation composition were investigated as part of an PhD study investigating vegetation, its corresponding trait composition, and their links to active layer depth. Frost tubes were installed to measure active layer depth, linking to the GLOBE program by NASA (https://www.nasa.gov/solve/feature/globe), a worldwide outreach program including scientists, students and citizens and promoting science.

The IsA (Isfjorden-Adventfjorden) high-resolution marine time series station is the marine endpoint of the BIG gradient. The station was established in 2011 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 to untangle natural year to year variation and long-term climate related alterations. Data on hydrography, 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.

Monthly time-series sampling continued in Billefjorden (the BAB station). While IsA is very much influenced by influx of warm Atlantic water and can be regarded as a model system for a future "Atlantified" Arctic, Billefjorden has a sill limiting inflow and is normally ice-covered during winter and spring. AB exploits this natural gradient to investigate possible differences in biodiversity and seasonal development between two contrasting Arctic "sea climate" scenarios.

In partnership with researchers at NMBU and Climate-ecological Observatory for Arctic Tundra (COAT), AB is participating in long-term, longitudinal research on Svalbard reindeer in Nordenskiöld Land. This research was initiated in 1995 and has collected individual-based data on survival, reproduction, physiology, and behaviour of 1,032 reindeer over the years. In 2021 a UNIS PhD student started investigating the behavioural and physiological responses of Svalbard reindeer to changing vegetation resulting from climate change. In April 2021, 159 reindeer were captured in Reindalen, Semmeldalen, and Colesdalen of which 60 were fitted with GPS collars and bio-loggers that measure heart rate and body temperature. These data will be coupled with on-the-ground measurements of vegetation in key habitats used by reindeer collected throughout summer and autumn, to reveal how behavioural decisions in response to phenology of forage affect fitness and population dynamics of reindeer. Furthermore, we initiated a three-year experimental study at the old aurora station in Adventdalen evaluating timing of senescence of reindeer forage in response to "extreme" temperature increases predicted for the Arctic. Data from 2021 revealed that in addition to increases in biomass observed in previous studies, grasses had delayed senescence when exposed

to warmer temperatures. These results suggest a future of prolonged access to abundant forage for Svalbard reindeer as temperatures increase.

The Nansen Legacy project is a multidisciplinary research project involving 10 Norwegian research institutions. Researchers are investigating the impact of climate change on the Northern Barents Sea and adjacent Arctic Basin using multiple research expeditions. AB staff participated in five Nansen Legacy cruises during 2021.

During 2021 monthly sampling of the marine time series stations IsA and BAB were maintained to compare biodiversity between two contrasting climate regimes. A summer sampling campaign to Eastern Svalbard was also carried out with the help of the coastguard vessel KV Barentshav. This campaign was part of the ACCES project (*De-icing of the Arctic coast: Critical or new opportunities for ecosystem services and marine biodiversity?*). Led by UNIS where Norway, USA, Canada, Poland, and Denmark work closely together in a pan-Arctic coastal perspective. One very important task was accomplished in 2021: to provide the first overview of Svalbard coastscapes.

In the ACCES project, we also investigate the ice algae and metazoan biodiversity in fjord ice in Svalbard. From March to June 2021, a larger spatial and temporal sea ice field campaign was conducted. Heavy snow falls in April efficiently blocked sunlight from entering the sea ice and the sea which led to very low ice algal biomass in Svalbard in 2021.

TERRA is a new project, funded by the Research Council of Norway / FRIMEDBIO. The aim is to characterize the interactive effects of climatic change and goose herbivory on soil organic carbon degradation and nitrogen mineralization rates. In particular the focus is on root-associated organisms and soil microbial function in the in the newly exposed active layer. The overall aim of TERRA is to determine how effects differ between contrasting High Arctic habitats and to up-scale across important Arctic ecosystems.

The Catchment to Coast (C2C) is a new interdisciplinary project funded by FRAM Centre including multiple partners, where both AB and AG contribute. C2C is taking an integrative 'catchment to coast' approach, bridging across ecosystem and disciplinary boundaries by assessing and quantifying cross-ecosystem linkages between terrestrial, freshwater, and coastal ecosystems.

In March the Conservation of Arctic Flora and Fauna terrestrial biodiversity status report was published with Steve Coulson leading the microarthropod section and with data from Svalbard forming an important element in the assessment.

GRADUATES 2021

PHD DEGREE:

ANNA EJSMOND
Temporal constraints on reproduction and growth in a seasonal environment. *(UNIS and University of Bergen)*.

MASTER´S DEGREES:

ELAINE RUNGE
Timing and magnitude of sea ice algal blooms in Svalbard archipelago: synthesis of chlorophyll a and driving environmental variables from 2007 to 2021. *(University of Copenhagen and UNIS)*.

INGRID VESTERDAL TJESSEM
Should I sex or should I go? Expansion of species niche through autopolyploidy. *(University of Oslo and UNIS)*.

DANIELA WALCH
Spatio-temporal variability in suspended particulate matter in a high Arctic estuary (Adventfjorden, Svalbard): A combined Field- and Remote Sensing approach. *(Potsdam University and UNIS)*.

LUIS WYSS
A time series analysis on DNA metabarcoding data from marine protist communities in a high Arctic fjord. *(ETH Zurich and UNIS)*.

bioCEED

BY STEVE COULSON (DEPUTY), SIMONE LANG (PROJECT MEMBER) AND TINA DAHL (ADVISER)

bioCEED develops biology education to fill future needs in science and society, and to facilitate teaching and learning across higher education in Norway and beyond. The activities are guided by our four focus areas: learning culture, innovative teaching, practical training, and outreach.

Establishing and maintaining a scholarly and collegial learning culture is a top priority for all engaged in bioCEED:

We are especially proud of the student-initiated project **SCOPE**, a student-led research conference on Polar environment at UNIS. In October, Bachelor, Master and PhD students were invited to present their work and share insights to their research and field projects. 150 students participated physically/online at the one-day conference, also including students from Svalbard Folkehøyskole.

The 3-day **Teaching Assistant course** was run in spring 2021. The course was primarily offered to PhD students across all scientific departments but was also open to master and postdocs. The course ran in collaboration with *iEarth*, focusing on central theories and concept of learning and teaching, written feedback, and field learning.

As part of the organizing committee, bioCEED also contributed to the **UNIS Learning Forum**, an annual event that provides an opportunity for all scientific and technical/admin staff at UNIS to meet and discuss teaching and learning and educational development. This is the eight-time Learning Forum have been run, this year with 95 participants including a group of 10 students.

Throughout 2021, bioCEED, the Academic Affairs department and scientific staff at UNIS have worked to create a common institutional duty work system to improve the allocation of **PhD teaching hours** within the 25% duty work part of their PhD position and professionalize the use of the PhD teaching resources.

Despite (or perhaps because of) the continued challenges imposed by Covid-19, we were very active in the innovative teaching focus area:

The development of the cross departmental **FieldPass** project have continued through 2021 which focuses on building teaching and assessment tools for field- and lab learning. Also, the development of the **online learning platform** Learning Arctic Biology and the local **Field Laboratory** in Bjørndalen have been a priority for bioCEED.

bioCEED has been involved in a project group working with the use and the furnishment of the **new student learning spaces** at UNIS. The process is led by bioCEED/AB-department in collaboration with iEarth and the Student Council. A need in such areas is due to increasing student numbers and the lack of informal learning areas at UNIS. These learning areas are also important in terms of supporting the development of generic skills within student-active research such as collaboration, communication, critical thinking, and problem solving and give demands on how we design the physical learning environment. The new learning areas will therefore be an important and necessary contribution to improving the learning environment.

The learning tool **Artsapp** for Svalbard covering all vascular plants in Svalbard except graminoids was launched and the ArtsApp key was tested and introduced as a tool within terrestrial biology courses at UNIS. Students have developed the graminoid part of the key which will be finalized in spring 2022.

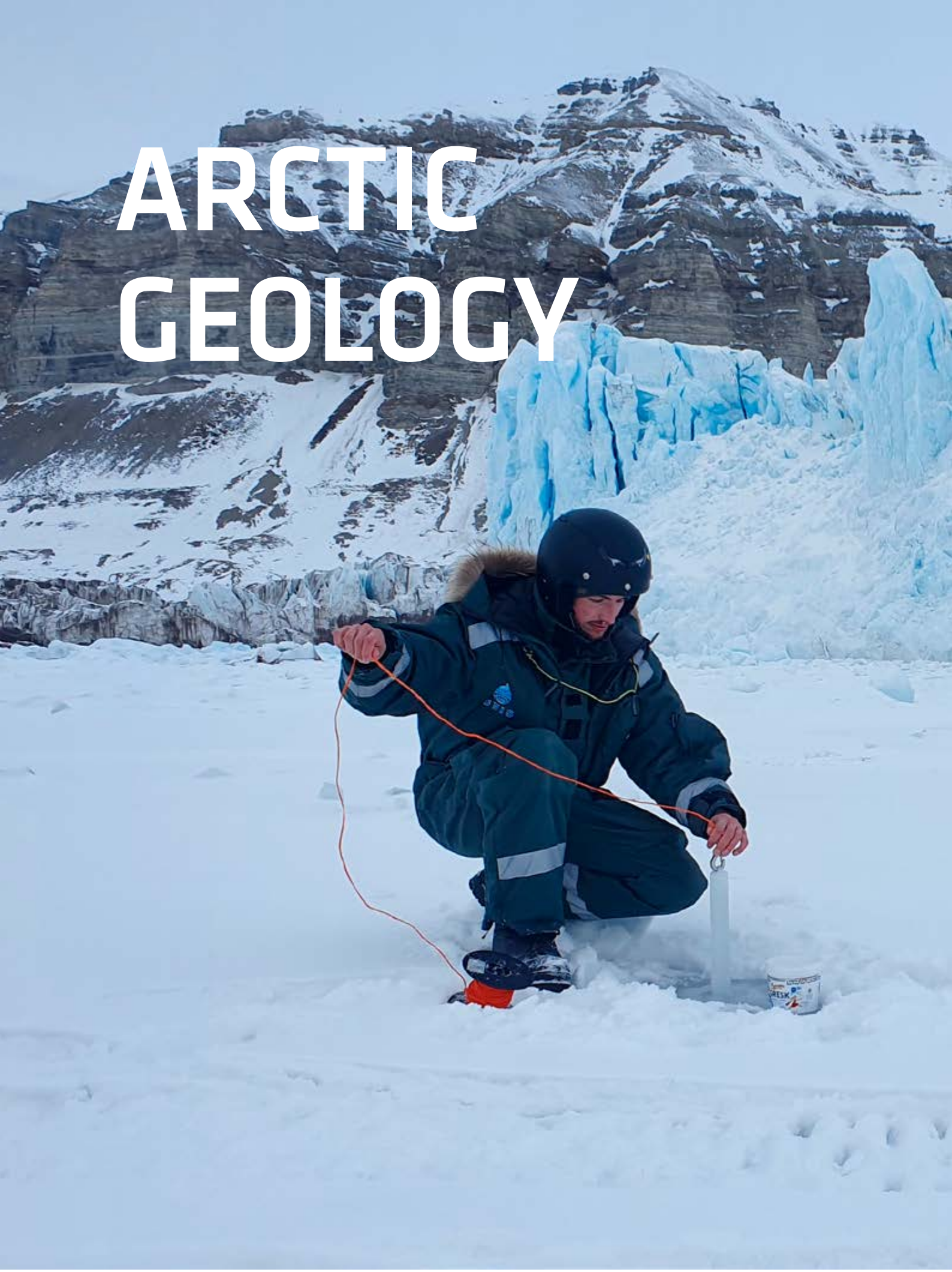
Dissemination and outreach are an important key part of the idea behind bioCEED. In 2021 we have developed a bioCEED UNIS homepage and a FieldPass project page. For a complete overview of our activities please have a look at bioCEED annual report 2021.

ABOUT BIOCEED

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

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

ARCTIC GEOLOGY



April 2021: Sampling freshwater beneath the sea ice as part of the CLIMAGAS project. Photo: Andy Hodson/UNIS.

BY MARIA JENSEN, HEAD OF DEPARTMENT

The Arctic Geology (AG) department provides education and research within geology and physical geography. The geological history of Svalbard is represented by excellent outcrops ranging from the Precambrian to the Cenozoic and contains unique records of palaeoclimate change. The outcrops combined with core material, geophysical and geochemical data provides a natural laboratory for basin studies and understanding of the earth system under different climate regimes and on different time scales. The present Arctic landscape and sea floor provides a laboratory for monitoring baselines and changes in response to present climate.

At the end of 2021 the department had six full time faculty positions, one professor emeritus, 14 adjunct faculty from universities in Norway, USA, Sweden, Denmark, the institute sector and industry, one staff engineer, 5 post docs and 6 PhD students.

EDUCATION

In 2021 we offered three full-semester BSc-level course packages, two BSc-level summer courses and a range of MSc and PhD courses. The course offer in the first semester of 2021 was significantly impacted by Covid-19, with reduced student capacity and MSc and PhD courses were cancelled for the spring semester. International student recruitment was lower than usual due to travel restrictions. Courses were carried out in a combination of online and physical presence during the spring, but all field excursions were done as normal.

All our teaching is field-based and focused on students working together on authentic problems. They get experience with data collection, data management and use of digital representations of the field (virtual outcrops, digital elevation models, drone imagery) as preparation for field work and/or for revisiting field sites in the classroom. This methodology allows for deep learning activities connected to field skills to allow students more time practicing observation and analysis skills, and also allows field relevant activities to be carried out during the dark season. For bedrock geology students svalbox.no developed by Kim Senger and team in the AG department has become state-of-the-art for geological data from Svalbard, including an ever-growing

February 2021: Excursion to Vendombreen. Photo: Andy Hodson/UNIS.

number of virtual outcrop models. Related initiatives for online access to surface landform data includes *SvalDEM* (monitoring of glacier fronts recession and development of their forefield through 3D models) and *SvalCoast* (geomorphological coastal map data).

The AG and AGF departments are partners in the Center for Excellence in Education *iEarth – Centre for integrated Earth Science Education*. The center is led by the University of Bergen and has participation from the University of Tromsø and University of Oslo in addition to UNIS. The aim of iEarth is to develop Norwegian geoscience education to the needs of the future, including developing curriculum in dialogue with society stakeholders and future employers, and raise the quality of the learning and teaching environments through student participation, collegial sharing of experiences and research on teaching and learning. IEarth at UNIS is supported by a 50% Education Chair position held by faculty member (in 2021 split 25/25% between AG and AGF departments), a focus area leader responsible for the topic "field learning" and a PhD student studying the role digital tools and virtual models plays in student learning in geology/geophysics. Smaller projects investigating learning environments and implementing changes in teaching at UNIS have been obtained by AG students and staff through iEarth seed grants.

An important aspect of iEarth is securing communication with the job market and society needs. iEarth obtains this through internship initiatives and alumni networks. The UNIS Arctic Geology Alumni club was started in the iEarth proposal phase and is continuing to grow and establish contacts with past Arctic Geology alumni. The club hosts webinars and produce newsletters for members.

RESEARCH

Our research falls broadly in three categories: present Arctic environmental change, past environmental change in a range of palaeoclimatic zones from Holocene high-resolution studies to deep-time, and basin geology in outcrop and subsurface.

The department staff has leading roles in several large projects. The *Research Centre for Arctic Petroleum Exploration (ARCEx)* – a large scale research collaboration between academia and industry (total funding 231 MNOK over eight years) ended in 2021. The center has provided cutting-edge, industry-relevant education experience and community for several PhD students and postdocs in addition to a large amount of publications during the existence of the center.

August 2021: On the AG-348 cruise they deployed a remotely operated vehicle (ROV) to inspect the ocean bottom. Photo: Riko Noormets/UNIS.

Other large industry-collaborations centered on Svalbard geology and subsurface data are *Suprabasins - Sedimentary Response to Growth of Major Extensional Fault Systems,* financed by the Research Council of Norway (RCN) and by industrial partners Aker BP ASA, Spirit Energy Norge AS, Equinor ASA, Lundin Norway and the NCCS project *Longyearbyen CO2 Lab* - characterisation of the Longyearbyen CO2 Lab caprock (which is also as an analogue for study in the North Sea). PhD student Peter Betlem participated in the IODP Expedition 396 (August - October 2021) as onboard scientist with the scientific aim of characterisation of the recovered basalts and implications for Basalt carbon storage in the Norwegian Sea. The UNIS expertise in subsurface conditions and characteristics are also being used toward new initiatives for developing geothermal energy as a future energy source for Longyearbyen. In 2021 the department participated in the pilot project test case to investigate options for providing the student housing building with geothermal energy. The department is part of the initiatives at UNIS for establishing research and teaching in sustainable energy.

The link between the subsurface and the modern Arctic environment through methane seeps is being studied in several projects. Andy Hodson is leading the project *CLIMAGAS* (funded by RCN) which has sampled every perennial spring in Nordenskiöld Land. A striking result is that most winter outflows are in the glacier forefields, and almost all of them contain super-saturated levels of methane. All pingos with outflows also produced methane, at even higher concentrations. New projects have resulted from this research, including a SIOS Innovation Award for continuous methane emission monitoring at the Lagoon Pingo (*TerraSeep*, led by Andy Hodson), and *METHANICE* – a study of the biogeochemistry and microbiology of the same site. Gabby Kleber (external PhD, CLIMAGAS and TerraSeep partner) is entering her second year of *HydroSurge*, a project that looks at the implication of glacier dynamics for methane outgassing. In so doing, the project has documented the impressive surges occurring in Rindersbukta.

UNIS expertise has been directed toward Antarctica with the RCN project *BIOICE*, which now enters its final stages. In partnership with the Norwegian Polar Institute and the Universities of Aberystwyth and Northumbria, BIOICE has looked at so-called blue ice areas on the Antarctic continent and how they allow near-surface melting to support microbial life in small habitats known as cryoconite holes. Dr. Aga Nowak has mapped all the habitats at a fine resolution and used this to understand controls upon their distribution and the availability of nutrients.

Tidewater glaciers in the fjords of Svalbard provide an excellent opportunity to study the physical environmental drivers and processes and the resulting submarine geomorphological and sedimentary records at their marine-terminating margins. The focus of Riko Noormets' research is to study these fjord environments to unravel the complexity of physical processes driving ice loss from calving marine-terminating glacier margins. This work was carried out through several projects in different fjords in Svalbard using both conventional ships as well as latest autonomous survey technology.

As part of glacier margin investigations, the *Multi-purpose Autonomous Surface vessels for Polar marine research (MASP)* project led to launching of the ASV Kuninganna. The ASV Kuninganna, equipped with latest multibeam technology, was successfully deployed in Wahlenbergfjorden where it mapped the glacier face of Etonbreen from top to seabed with unprecedented resolution and produced a wealth of new oceanographic, geological and glaciological data.

On-land studies of environmental change has focused on freshwater runoff, landscape change particularly in coastal and slope environments, and permafrost.

Aga Nowak has led the *SvalHydro* initiative summarizing results of Svalbard Hydrology from 1970- 2019, initiated and carried out monitoring of sediment transport and erosion in Longyeardalen in collaboration with Lena Rubensdotter (NGU and UNIS) and mass balance monitoring of Bogerbreen.

Monitoring of coastal change was carried out through projects funded by the Svalbard Environmental Protection Fund (*DynaCoast and MovingCoast*, led by Maria Jensen in collaboration with the Geological Survey of Norway (NGU) and University of Caen, France. Results from morphological mapping, drone imagery and aerial photo analysis combined with field observations are being used to establish baseline data and categories of coastal change and link them to risks around for example cultural heritage. The group has had information meetings for participants from Longyearbyen Community Council, the Governor of Svalbard and national environmental and cultural heritage management.

Reconstruction of past environments and palaeoclimate parameters are the key to prediction of future climates and Svalbard has the unique possibility of studying both cold and warm Arctic climates of the past, in addition to the longest palaeoclimate record in the Arctic. On the Quaternary time scale Mark Furze is involved in several projects including both glacial and interstadial sea level variations in Svalbard and across the Arctic. The *Arctic Quaternary Ice Shelves* project, led by Mark Furze, investigates the geological signature of former ice shelves across the Arctic at the end of the last glaciation. Other projects include *CRYOCARB* - investigation into the Marine Isotope Stage 3 Hinlopen Slide; *SHERBET* - investigation into deglaciation and sea-level history of western Spitsbergen and *Delta R* – developing revised marine reservoir calibration terms for circumpolar radiocarbon chronologies. A collaboration project between the AG and AB departments, *Svalbard Neoglacial Bryophytes,* investigates age of mosses appearing beneath retreating plateau ice caps and their species composition.

In the Early Cenozoic (ca. 60-40 million years ago) the Arctic was warm. The coal seams in Svalbard trapped high resolution information of the atmosphere, dust and forest fires during this time, and we have studied the geochemical signatures of the warm Arctic world through coal samples from the mines in the RCN funded *Coal – the ice core of the warm past* project led by Maria Jensen. 500 exploration drill cores through the Central Tertiary Basin allows us to do high detailed 3D reconstruction of the paleolandscape at the same time and link landscape and palaeoclimate in a way that does not exist elsewhere in the Arctic.

Initiatives to make use of the long deep time palaeoclimate record in Svalbard are led by Kim Senger and Aleksandra Smyrak-Sikora. The aim of the *RockVault* project is to make use of the valuable drill cores records in Svalbard and possibly initiate new drilling campaigns to target the time intervals where palaeoclimate information is particularly relevant or lacking. Kim Senger and Aleksandra Smyrak-Sikora are co-leading the *Svalbox 2.0 - Fair geoscientific data from Svalbard*, focusing on the HALIP volcanic event in addition to data collection for Svalbox.

The permafrost group is active in the *Svalbard Integrated Arctic Earth Observing System (SIOS) - InfraNOR*, national infrastructure project funded by the RCN. A large permafrost drilling campaign was done in spring 2021 to finalise the permafrost boreholes needed to expand the observation infrastructure around Longyearbyen. Two 20 m deep boreholes were drilled in the mountains around Longyearbyen in addition to one reaching 100 m in Endalen.

The UNIS Strategic Pilot Project *Developing a permafrost and meteorological climate change response system to build resilience in Arctic communities (PermaMeteoCommunity)* is coordinated by Hanne H. Christiansen, with participation from Aleksey Shestov (AT), Marius Jonassen (AGF) and Graham Gilbert (AG) in addition to Longyearbyen Community Council, Telenor, Instanes AS, NVE and Met.no as other partners. A drilling campaign was to map the extent of sediment filling Longyearbyen valley and determine its permafrost content and type were performed. An inclined borehole to record temperatures below the Kulturhuset building in Longyearbyen was also done. A new meteorological station with online data access is planned in the centre of Longyearbyen.

The RCN funded *INTPART - Landscape and infrastucture dynamics of frozen environments undergoing climate change in Canada, Norway and Svalbard (FROZEN CANOES)* which UNIS is leading, has been prolonged through 2022 due to the pandemic. Hanne H. Christiansen has been involved in the ENOVA funded project *Utvikling av termisk energiforsyning på Svalbard basert på dype energibrønner,* providing basic permafrost knowledge based on the basic permafrost research done at UNIS.

GRADUATES 2021

PHD DEGREES:

THOMAS BIRCHALL
Pore Pressure Regimes of the Northern Barents Shelf – Implications for Fluid Flow.
(UNIS and the University of Oslo).

HOLT JOHN HANCOCK
Snow avalanche controls, monitoring strategies, and hazard management in Svalbard.
(UNIS and the University of Oslo).

HANNA RÓSA HJÁLMARSDÓTTIR
New insight into the Taxonomy, Biostratigraphy, and Palaeoecology of Jurassic – Cretaceous Arctic Foraminifera.
(UNIS and the Natural History Museum, University of Oslo).

MASTER´S DEGREES:

URSULA ENZENHOFER
An observational study of the snow and firn regime at four Arctic glaciers, Svalbard.
(Universität für Bodenkultur Wien and UNIS).

MARJOLEIN GEVERS
Links between glacial meltwater and proglacial groundwater upwellings at Scott Turnerbreen, Svalbard.
(University of Oslo and UNIS).

ANNA STELLA GUÐMUNDSDÓTTIR
Variations in depositional environments of the Paleogene Firkanten Formation across Adventdalen, from Operafjellet to Breinosa.
(University of Gothenburg and UNIS).

NIL RODÉS I LLORENS
Gas hydrate stability and distribution in the fjords of Western Spitsbergen, Svalbard archipelago.
(Saint Petersburg State University, Hamburg University, Bremen University and UNIS).

ANNA BØGH MANNERFELT
3D modelling and interpretation of depositional elements in the Aspelintoppen Formation, Spitsbergen, Svalbard, a facies analysis. *(University of Bergen and UNIS).*

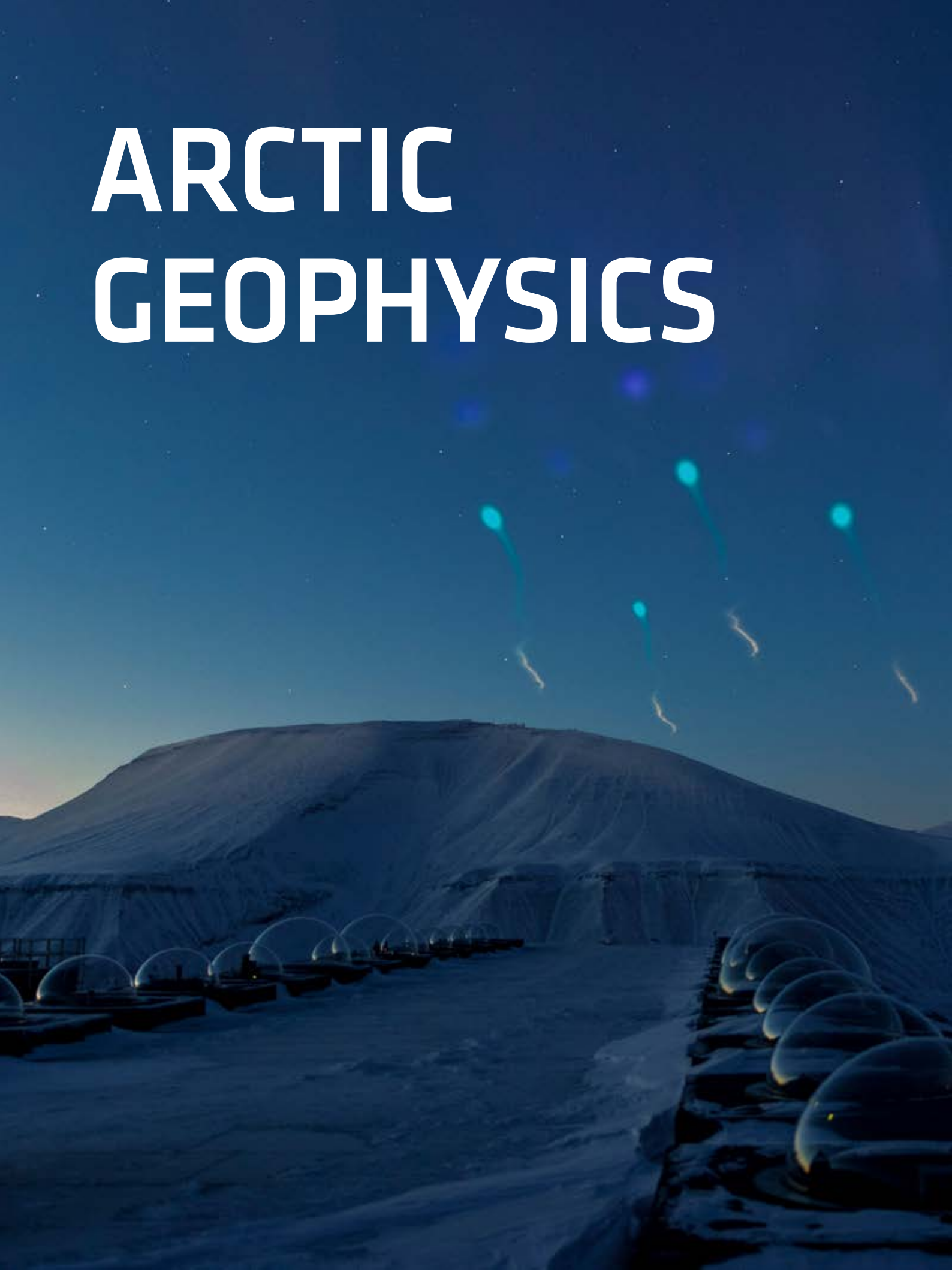
AMANDINE F.J.M. MISSANA
Mapping and dating Late Holocene advances of Nansenbreen on Erdmannflya, Svalbard.
(Stockholm University and UNIS).

AMÉLIE ROCHE
Neoglacial plateau ice cap behaviour in Central Spitsbergen constrained by subglacially preserved vegetation.
(UiT The Arctic University of Norway and UNIS).

RENATO SPERANDIO RODRIGUES
Impacts of untreated wastewater disposal on recreational water quality at two Arctic locations.
(NTNU, UNIS and Technical University of Denmark).

KATRIN WAGNER
Hydroclimate Reconstruction from Annually Laminated Lake Sediments from Kapp Linné, Svalbard, Norwegian High Arctic.
(Goethe-University Frankfurt am Main and UNIS).

ARCTIC GEOPHYSICS



December 2021: The NASA C-REX-2 rocket was launched from Andøya to study vertical winds in the vicinity of the dayside cusp region. The payload were canisters filled with Barium, Strontium and Trimethyl that when released created spectacular clouds, as seen here from the roof of the Kjell Henriksen Observatory. Photo: Mikko Syrjäsuo/UNIS.

BY DAG A. LORENTZEN, HEAD OF DEPARTMENT

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

The department had at the end of 2021 nine full time faculty in the fields of oceanography, meteorology, remote sensing, and space physics. The department also had three postdocs, one project researcher, 11 adjuncts and four PhD candidates. In addition, two engineers are working in the department.

EDUCATION

Courses are offered in all the research fields within the department. For 2021 five bachelor courses were given as well as four master/PhD courses. The Covid-19 effect was still discernible with a general reduction in ECTS production compared to normal years, but with a marked increase compared to 2020. It should also be mentioned that all master/PhD courses were cancelled at UNIS for the spring semester 2021 – with the exception of the two master/PhD Space Physics courses AGF-301/801 and AGF-304/804, since these are full semester courses. The ECTC production from guest students remained stable compared to previous years. The meteorology group has been part of two interdisciplinary groups spanning several UNIS departments, that have laid the foundation for two new course packages at UNIS focusing on renewable energy and sustainability.

RESEARCH

Space physics

The space physics group is part of the *Birkeland Centre for Space Science* – a centre of excellence in space physics based at the University of Bergen. The space physics group operates two large scale research facilities, the Kjell Henriksen Observatory (KHO) and the SuperDARN radar.

The activity at KHO was high during 2021 with full operation of the observatory, with 29 optical instruments operating 24/7 in the dark period and 17 non-optical instruments that run year-round. The observatory actively supported two rocket campaigns in 2021. The first was launched in November (JAXA – SS-520-3) by Andøya Space from SvalRak Ny-Ålesund to study the daylit cusp aurora. The second was launched in December (NASA C-REX-2) by Andøya Space from Andøya to study vertical winds in the vicinity of the dayside cusp region. The payload consisted of Barium, Strontium and Trimethyl aluminium canisters that when released creates spectacular clouds when illuminated by the sun. These clouds are then used as tracers for the motion of charged and neutral particles that gives an insight into the wind system in the ionosphere. These winds affect polar orbiting satellites causing them to slow down when they enter the area of study.

April 2021: The AGF-211 course went on a cruise with M/S Polarsyssel to Dicksonfjorden. Photo: Marcos Porcires/UNIS.

After a comprehensive study, the rebuild of the SuperDARN radar antenna array was started in 2021 with the rise of the masts for the interferometer array. Steel poles are now put into the ground at each end of both the interferometer array and the main array. The plan is to build the main array in May 2022, and to have the radar operational during fall 2022.

The ionosphere/magnetosphere team continues to work on understanding magnetosphere / ionosphere coupling mechanisms with a focus on energy and particle flow both into and out of the polar ionosphere. This has been done using a multitude of studies combining, primarily, radar and optical data. In addition to the SuperDARN radar, the team operate two other HF instruments, a Doppler sounder (PRIDE) and an ionosonde. The PRIDE *(Polar Research Ionospheric Doppler Experiment)* instrument continues to function well. The ionosonde is temporarily switched off for maintenance and in preparation for the new SuperDARN radar. A statistical study on electron density depletion using ESR was published in January 2021, and we continued with further studies on the early morning depletion region identified in Bjoland et al (2021). In the past year the primary focus has been on investigating how this region is affected by geomagnetic and solar wind conditions. The INTPART project (https://research.unis.no/mapat/resulted) has been extended until December 2025, due to the Covid-19 situation.

The team has taken the lead in the 'Upper Atmospheric' component in the up-and-coming SIOS SESS recommendation synthesis report. This report aims to put forward a coherent strategy for the science roadmap on Svalbard based on the recommendations made in the SIOS SESS report chapters from 2018 – 2021. The team were the EISCAT ground support crew for the CREX-2 rocket campaign.

Katie Herlingshaw successfully defended her PhD thesis in 2021. Katie had developed a new method to identify small scale flow channels in SuperDARN ionospheric radar data. Her PhD was the first large scale study of these features and revealed the statistical characteristics of the channels in terms of scale size, velocity magnitude and driving mechanisms.

The middle atmosphere team focuses on detection and characterisation of particle precipitation, and studies of the effects of high-energy particle precipitation on the Earth's atmosphere. One of our specific themes is pulsating aurora, which is a type of diffuse aurora that relates to energetic electron precipitation. We showed that this type of aurora occurs frequently and can lead to the production and accumulation of odd nitrogen in the mesosphere, which then descends into the stratosphere during the winter season. Pulsating aurora will thus contribute to the natural depletion of stratospheric ozone, in addition to depleting mesospheric ozone. Our studies have also demonstrated that the impact area of particle precipitation during pulsating aurora is often comparable to that during auroral substorms but extends further equatorward and later into the morning hours. These findings will be used to model the atmospheric

August 2021: A new weather station is set up at Bohemanneset in Isfjorden. Photo: Charlotte Sandmo/UNIS.

response to energetic electron precipitation in a more realistic way during pulsating aurora.

Air-Cryosphere-Sea Interaction (ACSI)

The remote sensing team participated in the ESA Climate Change Initiative+ (CCI+) Sea Ice work, developing satellite altimeter retrieval. The aim of CCI+ is to create a long, consistent global time series of sea ice related essential climate variables - such as sea ice thickness - derived from satellite measurements. Currently, CCI+ sea ice thickness time covers the winters of 2002 to 2020 but will be expanded in CCI+ Phase 2 in 2022 and 2023.

UNIS organized an online Thematic User Group (TUG) meeting for the ESA project Cryo-TEMPO in November 2021. The purpose of the meeting was to collect experiences and recommendations from the thematic users to improve future CryoSat-2 data. Similar meetings are planned for 2022 and 2023 as well.

The meteorology team leads a work package in the four-year RCN project *Risk governance of climate-related systemic risk in the Arctic* (ARCT-RISK). The primary objective is to develop knowledge and tools to make sense of and deal with effects of climate change on society's ability to protect the life and health of its citizens and to maintain critical infrastructure and function. The Arctic plays a key role in understanding and mitigating the challenge of climate adaptation, as the climate already is changing more rapidly here than anywhere else in the world. This means that successful risk governance strategies developed in response to destabilized climate conditions in Arctic locations, serve as important guidance for future climate change adaptation in mainland Norway and other relevant parts of the world. The project has funding for one PhD position, one researcher position and one postdoc position, all of them allocated to the Arctic Safety Centre at UNIS.

The team also leads a work package in the UNIS strategic pilot project *Developing a permafrost and meteorological climate change response system to build resilience in Arctic communities* (PermaMeteoCommunity). The project combines permafrost research and engineering application, as well as modelling and field observations to create new knowledge and innovation. The climate response system will provide guidance for local authorities in planning and making decisions related to permafrost changes. The model will have transfer value to other Arctic settlements and can act as a standard for local and regional decision making on short and long-term scales.

The meteorology team has initiated the build-up of a network of weather stations around Isfjorden called Iwin *(Isfjorden weather information network)*. Providing online, real-time weather data from the area, the Iwin network benefits ongoing and future research at UNIS as well as people conducting field activities in the area, such as UNIS, tourist companies, Sysselmesteren, etc.

The oceanography team is deeply involved in the *Nansen Legacy* project. The team's main delivery into the

June 2021: AGF-353 students on excursion to Linken on Hiorthfjellet. Photo: Lars Henrik Smedsrud/UNIS.

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. UNIS was leading the Winter Process Cruise, conducting observations on processes that control position and variability of the polar front in the northern Barents Sea and the distribution of Arctic and Atlantic water masses. Historically, the Northern Barents Sea have been difficult to access in winter, but it is during this time of year that important atmosphere-ocean-processes are taking place and the heat fluxes between the sea and the atmosphere are the greatest. These processes are important for the rest of the year through affecting, among others, the extent and variability of the sea-ice cover, the distribution of water masses and circulation patterns, and the availability of nutrients for plankton before sunlight returns. Advanced research platforms like ocean gliders and an Autonomous Unmanned Vehicle (AUV), armed with oceanographic instruments, were deployed to find, and measure the Polar Front. Moorings were deployed in strategic positions capturing the inflow of warm Atlantic water, and CTD (conductivity, temperature, and depth) and current profiles were collected in repeated sections and over time at specific stations across the front and across important currents flowing in the Barents Sea.

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 was deployed in Isfjorden in October 2020 and running until October 2021. 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, 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 are the long-term measurements by moorings of the exchange flow between the shelf and Isfjorden, one at the mouth of Isfjorden and one further inside the fjord. New oceanographic instruments were deployed for the Isfjorden mooring time series and will ensure continued research activities and time series in Isfjorden.

Standard hydrographic sections in Isfjorden and on the shelf outside have been maintained by annual UNIS student cruises since 1995 in the autumn and since 1999 in spring and luckily also in 2021 but with some reduced coverage in spring due to the Covid-19 restrictions. These ocean climate time series are important for our continuous research on the "Atlantification" of the West Spitsbergen shelf and fjords (warmer and saltier) that we have seen taking place in Isfjorden during the last decades. Storfjorden, located east of Spitsbergen, is another area of interest and is one of the last ocean areas in the Barents Sea with dominantly Arctic conditions. However, this is now changing with the ongoing "Atlantification" taking place around Svalbard, and it is crucial to observe these changes while they are happening and compare with historical data.

The collection of hydrographic and current data obtained by UNIS are published in the UNIS hydrographic database (UNIS HD; Skogseth et al., 2019) and as separate data files for each mooring deployment (Skogseth and Ellingsen, 2019) in the Norwegian Polar Institute's dataset catalogue.

The Yermak Plateau acts as a guidance or barrier for the West Spitsbergen Current, carrying warm and saline Atlantic Water, which either crosses the plateau or flows around it to enter the Arctic Ocean. Combining a 2-year ocean observing program (from the RCN REOCIRC project) with altimetry, re-analysis wind data and the UNIS HD gave new knowledge on the variability and dynamics of the Spitsbergen Polar Current and the Svalbard Branch crossing the Yermak Plateau (Nilsen et al, 2021b). Episodes of large heat flux toward the Arctic Ocean, capable of melting one meter of sea ice over a large area in only matter of days, were calculated in connection to a strong windstorm in January 2016. This demonstrates that the heat flux controlled by the volume transport variation can significantly amplify the warming trend during years with anomalous atmospheric circulation patterns with more frequent low-pressure systems over Svalbard during winter.

A new numerical ocean circulation model with a 500 m horizonal resolution was set up for Isfjorden and the shelf outside (Isfjorden S500) by UNIS and the Institute of Marine Research. Model data has already been validated against the time series data at the mouth of Isfjorden and results so far are very promising. This model will be very valuable for more dedicated process and case studies in Isfjorden to increase our knowledge on the interaction between atmosphere and ocean and how this affects the shelf-fjord exchange mechanisms and the sea ice cover.

The team has also measured dissolved methane in seawater over several years and published a paper in 2021 where a time series (2015–2017) of dissolved methane concentrations combined with hydrographic data from Adventfjorden and Tempelfjorden were presented. Both fjords remained permanently supersaturated, and a pronounced temporal and spatial variations in the methane excess level was found. The study revealed that seasonal water transformations were key to seasonally changing methane pathways including potential sea-air exchange. Methane enters the bottom waters from the sediments. Deep convection during winter transported the methane vertically so that the methane from the bottom water reached the water-atmosphere interface and was lost to the atmosphere. During the warm season, the fjord water became stratified and methane transport occurred mainly laterally following the bottom current out of the fjord. The seasonally changing hydrographic conditions strongly triggered the methane spreading in both fjords and point to a switch between the atmosphere and ocean as main sinks in winter and summer, respectively.

GRADUATES 2021

PHD DEGREE:

KATIE HERLINGSHAW
Characterising Mesoscale Fast Flow Channels in the Polar Cap Ionosphere.
(*UNIS and University of Bergen*).

FASIL TESEMA
Energetic electron precipitation of pulsating aurorae and their mesospheric effects.
(*UNIS and University of Bergen*).

MASTER´S DEGREES:

FREDERIKE BENZ
Topographically trapped waves in the Isfjorden Trough.
(*Universität Hamburg and UNIS*).

ANTON GOERTZ
Poleward moving auroral forms and dayside flow channels.
(*Goethe Universität Frankfurt am Main and UNIS*).

CHARLOTTE MAARTJE VAN HAZENDONK
On solar proton cutoff latitudes measured by GPS satellites. (*Eindhoven University of Technology and UNIS*).

MATTHIAS MARKUS HENKIES
The wind climate in Adventdalen, Svalbard.
(*Ludwig-Maximilians-Universität München and UNIS*).

MAX NÜSSLE
Heat transfer simulations of crevassed glaciers.
(*University of Stuttgart, NTNU and UNIS*).

ARCTIC TECHNOLOGY

April 2021: AT-211 students on fieldwork in Svea, Van Mijenfjorden. Photo: Aleksey Marchenko/UNIS.

BY GIJSBERT BREEDVELD, HEAD OF DEPARTMENT

The Arctic Technology (AT) department conducts research and education in Arctic environmental technology and Arctic engineering. The department focuses on five main societal challenges with an emphasis on High Arctic systems: soil physics and geotechnical engineering, sea ice properties and structure interaction, sustainable Arctic energy, contaminants, and their effects on the ecosystem as well as risks related to avalanches and land/rockslides.

In 2021, the department's staff comprised three professors and one associate professor, two research associates, one post-doctoral fellow, four PhD candidates, one manager of the Arctic Safety Centre, one staff engineer, and 11 adjunct 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, mechanical, and chemical properties of sea ice and soils, in addition to time dependencies and failure modes of such materials as well as fate and transport of contaminants onshore and offshore. This gives students the opportunity to study both the theoretical and practical aspects of Arctic environmental technology and engineering, and further to benchmark analytical and numerical models and simulations, in order to provide better assessments and predictions for Arctic societal challenges and contribute to sustainable environmental development. In 2021, the department offered two courses at bachelor level, and 17 courses on master- and PhD level, where only the spring semester courses were conducted. Fieldwork was performed on the sea ice in Svea and soil sampling at the NGTS test field near UNIS with subsequent soil characterization and soil strength testing in the UNIS laboratories. The main focus in 2021 has been to enable master student to come to UNIS to work on their individual research projects. About 20 master students took courses and carried out parts of their thesis work at AT. Five students completed their MSc thesis at the department in 2021 and one PhD student acquired the doctoral degree.

RESEARCH

The department conducted research in soil physics and geotechnical engineering, sea ice properties and structure interaction, sustainable Arctic energy,

October 2021: Laser scanning is being used to monitor the newly built avalanche protective wall in Longyearbyen. Photo: Nataly Marchenko/UNIS.

contaminants, and their effects on the ecosystem as well as risks related to avalanches and land/rockslides.

Soil physics and geotechnical engineering

Due to permafrost conditions in the Arctic, it is challenging to establish stable foundations for infrastructure. The department has several test sites and is monitoring existing buildings in Longyearbyen.

The installation of the test setup for piles in marine permafrost clay at the NGTS site east of UNIS was finished in 2020 and has been monitored throughout 2021. The main focus is on the pile tip resistance in the clayey marine soil at the site. The testing will run until 2023 to register failure or excessive settlements. The data will be used to better understand soil creep behaviour in the warming permafrost soil. Several master students are involved in this work and contribute significantly to the improved knowledge of the strength and thermal properties of the Longyearbyen underground.

The interdisciplinary *PermaMeteoCommunity* project focuses on developing resilience in Arctic communities by providing a scientifically developed coupled permafrost and meteorological climate change response system. This system will assist decision making by providing real-time key geoscientific observations affected by increasing climatic changes. The strength and creep rate of frozen soil depends on temperature.

Warming permafrost will require adaptation in foundation design to fulfil the main loading criteria: enough resistance and acceptable settlement rate. When it is not feasible to naturally maintain the existing ground thermal regime, artificial ground freezing has to be introduced, or the design must be adapted to one that accepts temperature changes in the permafrost, for example, end-bearing piles.

The foundation of the new waste facilities *(Miljøstasjonen)* in Longyearbyen is based on a cooling plate design. AT runs a master project on modelling the thermal regime in the permafrost under the cooling plate, accounting for heat transfer from the building and heat fluxes from the ground and the sea floor, with the aim to minimize operation costs and energy consumption. Moreover, together with the Longyearbyen Community Council we are looking into developing a concept utilizing solar-produced electricity for powering the active cooling plate foundation for *Næringsbygget*. To monitor structure performance, soil thermistors have been installed. The Coop store in town also utilizes active cooling to stabilize the permafrost below the foundation. These cases generate valuable data and allow for modelling and analyses by our students.

In the *Nordic Research Infrastructure Hub on Cold Climate Engineering* (COLDHUB), collaborative research aims to solve the cold climate engineering problems we face with the warming climate. Coastal erosion and ice fracturing issues are the main elements of the research and education in the project. Photogrammetry techniques are utilized to monitor the annual coastal retreat along the road to Bjørndalen. This project is led by Aalto University together with NTNU, UNIS, and DTU as partners.

Laser scanning allows creating 3D image with millimetre accuracy and repeated scans can reveal changes in landscape and structures. Spring and autumn monitoring of the roads in Longyearbyen document the strong effects of permafrost degradation. This technique has

also been used to monitor the newly built avalanche protective wall, giving promising results which are important for the local community and an important future research site.

Ice mechanics and offshore engineering

Sea ice and lake ice usually has columnar structure and consists of grains extended in the vertical direction. A set of tests were elaborated to investigate elastic, viscous and anelastic properties of columnar ice in different directions. Tests were performed with cores and beams cut from sea and lake ice in vertical and horizontal directions.

Laboratory and field tests on thermal expansion were performed by master students to compare thermal loads on sea ice and lake ice. This was funded by the Svalbard Field Grant. Field tests were performed in Vallunden lagoon in Van Mijenfjorden and in a freshwater lake near the lagoon. We discovered big difference in thermally induced stresses in sea ice and fresh ice depending on the depth. The difference is explained by stronger dependence of the coefficient of thermal expansion in sea ice from the temperature in comparison with fresh ice.

Dynamics and thermodynamics of sea ice and tidal effects on the Spitsbergen Bank were investigated to explain the characteristics of motion of drifting buoys equipped with GPS modems, accelerometers (IMU) and anemometers. We discovered that shear deformations of sea ice on Spitsbergen Bank were much higher volumetric deformations because the ice consisted of floes with relatively small diameters of few tens of meters. Combined action of wind and wave explained floes drift with speed above 1.5 m/s. To explain properties of the buoys drift near Hopen Island we elaborated analytical model of the interaction of semidiurnal tide with an island of elliptic shape.

Analysis of oceanographic measurements (CTD and ADCP profiling) on Spitsbergenbanken showed instability leading to water mixing in shallow regions, and generation of internal waves on the continental slope to the South-East of Hopen Island. Mixing of cold Arctic water on shallow depth reduces ocean heat flux and leads to water overcooling and fast formation of ice in cold weather. Local formation of sea ice on Spitsbergenbanken was confirmed by satellite images and ice maps. Over the last decades Spitsbergenbanken has been the most ice impacted area in the Barents Sea. Maximal annual occurrence of sea ice observed at 75° N was estimated to be more than 150 days.

Measurements of waves and sea currents in Longyearbyen harbour continued in 2021. In addition, we deployed IMU to monitor vibrations of floating plastic piers in the harbour to identify dangerous weather conditions when the pier could be damaged. It was discovered that waves and wind may influence high frequency vibrations in some places of the piers connected in a chain. Further data analysis is on-going.

Our increased understand of sea ice behaviour will be valuable input to safe marine operations in Arctic coastal waters and forming the basis for the online Geographical Information System (GIS) for the *Marine Emergencies in the Arctic* (MarEmAr) project.

At the outlet of the Longyear river a sand spit has developed over several years forming a coastal lagoon. The sand spit has moved 180 m towards the east since 2009. LiDAR scanning is used to document the dynamics

March 2021: The solar cell test panels in Adventdalen. Photo: Anna Sjöblom Coulson/UNIS.

of the system under the influence of ice formation and sedimentary processes. This makes the lagoon a very interesting research site for collaborative research, combining remote sensing with sedimentology and ice interaction.

Sustainable Arctic energy

One of the key focus areas at UNIS is to contribute to the energy transition in Longyearbyen. The coal-based powerplant will close down in 2023 and reliable sources of sustainable energy has to be developed. A new professor position has been established with the main focus on wind and solar energy, in addition to geothermal energy in collaboration with the department of Arctic geology. The major challenge is that there are no renewable energy systems developed for the Arctic, and systems must be tested in these cold climate conditions before applying them commercially. Further, to determine the feasibility of wind and solar power around Longyearbyen, and to better understand what controls the energy potential, investments have been made in monitoring equipment to collect necessary data.

Together with ongoing radiation measurements around Longyearbyen, a test installation in Adventdalen is used to investigate solar power production from regular and bi-facial panels, effects of environmental loads from wind, snow drift and accumulation. Solar panels have been installed at the new Elvesletta student housing, Longyearbyen airport and K-SAT on Platåberget, and generate valuable data for our on-ging PhD studies on how to adapt the use of solar energy in the Arctic.

Meteorological processes and wind energy is the topic of another PhD study. The meteorological processes are in many ways different from those further south due to the cold climate with midnight sun and polar night, topography, and have a very local character. To better understand what controls the specific wind conditions important for wind energy in the Arctic, the wind regime in Adventdalen is used as a case study. The potential of wind energy is also evaluated.

UNIS is highly involved in discussions with the local authorities and Store Norske in developing a feasible sustainable energy supply for the future that will be attractive also for other off-grid communities around the Arctic. To support this work, proposals for funding by the Research Council of Norway under the Knowledge building for society and industry programs have been submitted in collaboration with CICERO and SINTEF.

A course portfolio for a semester long study track on sustainable Arctic energy has been developed. It consists of three courses that build on each other and is presently implemented involving the mainland universities in Norway.

Environmental chemistry and toxicology

Fate and transport of contaminants under changing Arctic conditions is a main focus area contributing to a better understanding of environmental risk related to long-range and local sources of pollution. Research activities in the region of Longyearbyen, Ny-Ålesund and Barentsburg have been on-going, including monitoring the atmospheric, aquatic, and terrestrial environment.

In collaboration with the AARI Barentsburg chemistry laboratory and the Gdansk Technical University, the RCN funded project *Harmonising Environmental Research and Monitoring of Priority Pollutants in the Svalbard Atmosphere* (HERMOSA) has performed method testing and comparisons. This work will form the basis for an international thematic workshop on Svalbard atmospheric pollutant monitoring in 2022. Significant local air pollution in the Arctic were presented in the PhD thesis of Tatiana Drotikova, including an evaluation of polycyclic aromatic hydrocarbons (PAHs) emissions from coal burning at the power plant. Dispersion pattern of pollutants with from the source under changing wind direction were studied and, for the first time, oxygenated and nitrated PAHs were quantified in the Svalbard air.

Local sources of contaminants in the sea water were investigated in Ny-Ålesund and Longyearbyen, such as pharmaceuticals, personal care products (PPCPs) as well as per- and polyfluorinated substances (PFAS). The project *Reducing the impact of fluorinated compounds on the environment and human health* did a comprehensive study on local pollutant sources of PFASs in the Adventfjorden area as well as in Ny-Ålesund.

Exposure levels of PFAS on biota were studied in Adventfjorden. Benthic organisms, plankton and fish were included. PFAS levels in glaucous gulls have been investigated and compared with levels in glaucous gulls in Greenland. In Ny-Ålesund a project was initiated to study uptake of PFAS released from local sources in terrestrial and aquatic biota around Solvatnet in collaboration with NGI, NTNU and NPI.

A new PhD project is focusing on the fate and transport of mercury in the Arctic environment. Mercury release from permafrost, and chemical processes of mercury in Arctic soil can result in uptake in terrestrial biota, ranging from micro-organisms to vegetation and the dominating Svalbard herbivore reindeer. Both exposure levels and potential effects are studied.

GRADUATES 2021

PHD DEGREE:

TATIANA DROTIKOVA
Polycyclic aromatic compound (PACs) in ambient air of Svalbard. Concentrations, seasonal trends, sources, and transformation processes. *(UNIS and NMBU).*

MASTER'S DEGREES:

HAO-CHEN HUANG
Experimental study on creep of frozen marine fine-grained soil in Longyearbyen, Svalbard.
(NTNU, UNIS and Technical University of Denmark).

ELIZABETH JEAN MCMASTER
An experimental comparison of thermal-mechanical properties of freshwater and saline ice in Arctic environments.
(Delft University of Technology, NTNU and UNIS).

LISE BERNTSEN PENNE
Masseredningsoperasjon ved en cruiseskipsulykke utenfor Spitsbergen.
(University of Stavanger and UNIS).

ALEXANDRA PLISS
Evaluation of the capabilities of employment of electrokinetically-induced seismoelectric field to determine the geomechanical and filtration properties of the medium and laboratory studies of seismoacoustic signals on ice samples.
(Moscow Institute of Physics and Technology and UNIS).

KJERSTI BURAAS SNOEN
Pre-investigations for High Temperature Borehole Thermal Energy Storage. *(NTNU and UNIS).*

SYLVIA WEGING
Study of trace elements, natural organic matter and selected environmental toxicants in soil at Mitrahalvøya, to establish bias correction for studies of long-range atmospheric transported pollutants in Ny-Ålesund.
(NTNU and UNIS).

ARCTIC SAFETY CENTRE

BY MARTIN INDREITEN, GENERAL MANAGER

The Arctic Safety Centre (ASC) is co-located with the Arctic Technology department at UNIS, and 2021 was its second year of operation. The centre staff consists of a full-time general manager, four adjunct professors, and three full-time employees associated with the ARCT-RISK *(Risk governance of climate-related systemic risk in the Arctic)* project. Technicians from the Operations and field safety section have also contributed as instructors on safety courses arranged by the centre.

The centre's main task is to offer knowledge and expertise related to safe field activities in Svalbard. The centre also focuses upon societal safety and disaster emergency preparedness in an Arctic context, in which climate preparedness and climate adaptation are pivotal activities. These tasks and activities have been solidified in the Government's Strategy for innovation and business development.

EDUCATION

The centre offers 10 ECTS master's courses within Arctic Safety. The courses are designed in such a way that they can be taken individually or as a package. There are a total of 60 study places, but the courses have quickly become popular and have a lot more applicants than there are study places.

We have also been pleasantly surprised by the student retention in these courses, almost all students attend two or more courses. We believe this is down to the courses emphasizing the important cross-section between the theoretical aspects of safety and the applied context of the Arctic, and we utilize as many local stakeholders as possible in the teaching. The centre is also responsible for the mandatory 14 ECTS Arctic Nature Guide course Arctic Safety and Field Leadership.

RESEARCH

The ARCT-RISK project started in 2021 with the goal of developing knowledge and tools to make sense of - and deal with - the effects of climate change, societies ability to protect the life and health of citizens and maintain its critical infrastructures and functions.

The project was granted NOK 12 million from the Research Council of Norway and will run for three years. There are three positions related to the project and all positions have their workplace at the ASC.

October 2021: The Arctic Safety Centre was responsible for the HSE preparation and follow-up of safety plans in the Arctic Mass Rescue Operation (AMRO) exercise, led by the Governor of Svalbard together with multiple local and national actors.
Photo: Håkon Daae Brensholm/Visit Svalbard.

To achieve the project's objectives a transdisciplinary approach, involving perspectives from technology, safety science, natural science, and social science, is applied. The research group is collaborating closely with local stakeholders in Longyearbyen to achieve to objectives of the project. The Longyearbyen Community Council, the Governor of Svalbard, Telenor Svalbard AS, Nordkapp municipality, Skred AS, NVE and the ASC participate in the project's reference group.

In October, the centre organized the Arctic Safety Conference, an international conference with 60 participants. The aim was to bring together experts and practitioners to share new knowledge and best practices of Arctic safety. Selected articles from the conference will be presented in a separate special issue in the journal "Safety in Extreme Environments".

SERVICE

The centre is contracted by the Longyearbyen Community Council to provide weekly snow observations for the local avalanche forecasting system. It also delivers similar snow observations to KSAT-Svalbard in relation to their avalanche risk assessment of the KSAT road.

In 2021 the centre arranged and participated in several webinars, such as the Svalbard seminar with lectures on: "Natural hazards and climate change - what does this mean for your own safety on a trip?" ASC organized an open webinar with focus on safe travel with snowmobile before the start of the Easter holiday. This was a collaboration between ASC, UNIS, the Governor of Svalbard, Lufttransport and Hurtigruten Svalbard.

The centre was also responsible for the preparation of the HSE and follow-up of safety plans in the Arctic Mass Rescue Operation (AMRO) in October 2021. The exercise was structured around a cruise ship mass rescue operation and was devised by the Governor of Svalbard together with multiple local and national actors.

INNOVATION AND DEVELOPMENT

The centre is in close collaboration with Telenor Svalbard in the development of local avalanche monitoring sensors. The sensors use Internet of Things (IoT) technology to send snow depth measurements in real time to be used in avalanche warnings. The experience garnered from these sensors and the local avalanche warning system has also become the foundation for the ongoing DRIVA project in Nordkapp municipality. It has become success story of knowledge transfer from Svalbard to the mainland and is now an integral part of Nordkapp's local avalanche forecasting system.

SCIENTIFIC PUBLICATIONS 2021

UNIS affiliated scientific publications in channels authorized in the Norwegian Register for Scientific Journals, Series and Publishers.

Ali, A. M., Sanden, M., Higgins, C., Hale, S., Alarif, W., Al-Lihaibi, S., Ræder, E. M., Langberg, H. A., & **Kallenborn, R.** (2021). Legacy and emerging per- and polyfluorinated alkyl substances (PFASs) in sediment and edible fish from the Eastern Red Sea. *Environmental Pollution*, 280, 11. doi: https://doi.org/10.1016/j.envpol.2021.116935

Allaart, L., Schomacker, A., **Håkansson, L. M.**, Farnsworth, W. R., Brynjólfsson, S., Grumstad, A., & Kjellman, S. E. (2021). Geomorphology and surficial geology of the Femmilsjøen area, northern Spitsbergen. *Geomorphology*, 382, 16. doi: https://dx.doi.org/10.1016/j.geomorph.2021.107693

Ambrose, W. G., **Renaud, P. E.**, Adler, D. C., & Vadas, R. L. (2021). Naturally occurring rock type influences the settlement of fucus spiralis L. Zygotes. *Journal of Marine Science and Engineering*, 9(9), 0. doi: https://dx.doi.org/10.3390/jmse9090927

Andreeva, V. A., Apatenkov, S. V., Gordeev, E. I., **Partamies, N.**, & Kauristie, K. (2021). Omega Band Magnetospheric Source Location: A Statistical Model-Based Study. *Journal of Geophysical Research (JGR): Space Physics*, 126(6), 14. doi: https://dx.doi.org/10.1029/2020JA028997

Asplund, J., van Zuijlen, K., Roos, R. E., Birkemoe, T., Klanderud, K., **Lang, S. I.**, & Wardle, D. A. (2021). Divergent responses of functional diversity to an elevational gradient for vascular plants, bryophytes and lichens. *Journal of Vegetation Science (JVS)*, 33(1), 9. doi: https://dx.doi.org/10.1111/jvs.13105

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July 2021: A common eider *(Somateria mollissima)* with one of her offspring. Photo: Sil Schuuring/UNIS.

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