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Expeditions to Antarctica: ANT-Land 2019/20 Neumayer Station III, Kohnen Station, Flight Operations and Field Campaigns

Edited by

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Thomas Matz, Christine Wesche

with contributions of the participants

HELMHOLTZ

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ANT-Land 2019/20

05 November 2019 - 25 February 2020

Neumayer Station III, Kohnen Station, Flight Operations and Field Campaigns

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Contents

1. ÜBERBLICK UND VERLAUF

Tanja Fromm AWI

Die Sommersaison in der Antarktis ist die kurze Zeitspanne zwischen November und Februar, in der das raue Klima den Zugang zum Kontinent per Flugzeug oder Schiff zulässt. Während des Südsommers gibt es genügend Tage mit warmem und mildem Wetter, um umfangreichere Freiland-Arbeiten zu ermöglichen (Details in Kapitel 2: Weather conditions). Wissenschaftliche und logistische Aktivitäten finden gleichzeitig statt und beeinflussen sich gegenseitig. Dies erfordert eine sorgfältige Abstimmung und gegenseitige Rücksichtnahme von Wissenschaftlerinnen und Wissenschaftlern, Technikern und Logistikern hinsichtlich der verfügbaren Ressourcen. In diesem Expeditionsbericht dokumentieren wir die Aktivitäten des AWI und seiner Kooperationspartner an der *Neumayer-Station III*, am *Dallmann-Labor* und an anderen Stationen und Forschungsplattformen in der Antarktis.

Während der Sommersaison ANT-Land 2019/20 sind 23 Projekte an *Neumayer Station III*, *Dallmann-Labor* sowie eine Kampagne an *Dome C* und ein Projektteilnehmer auf der *SA Aghulas II* unterstützt worden. Einige der Projekte haben ähnliche Ziele, aber die meisten sind unabhängig voneinander. Sie gehören unterschiedlichen Disziplinen an, finden an unterschiedlichen Orten statt, verlaufen parallel, überlappen sich, haben unterschiedliche Längen und logistische Anforderungen. Wann immer möglich, werden verschiedene wissenschaftliche Projekte und logistische Abläufe kombiniert, um die Umweltbelastung zu minimieren und den Personalbedarf und die finanziellen Ressourcen zu optimieren. Dies bedeutet, dass einige Projekte vollständig von unabhängigem Personal durchgeführt werden, dass die Wartung für andere Projekte mit übernommen wird, oder dass sich verschiedene Projekte Personal teilen - wissenschaftlich und technisch. Die wichtigsten logistischen Meilensteine und Arbeitsvorgänge werden in Kapitel 3 ausführlich beschrieben.

Die Saison in der *Neumayer-Station III* ist eine Synthese aus Observatorien-Wartung, Langzeit-Projekten, Einarbeitung der neuen Überwinterer, Stationsbetrieb, Besuchen von Filmteams und zusätzlichen Gastprojekten. In den Kapiteln 4.1 bis 4.3 wird die jährliche Wartung der Observatorien beschrieben. In dieser Saison wurde das Observatorium für Luftchemie durch Projekt VACCINE erweitert (Kapitel 4.11). In den Kapiteln 4.4 bis 4.14 geht es um Langzeit-Projekte aus unterschiedlichen Forschungsgebieten, z.B. Meereis (AFIN), Tierwelt (PALAOA, SPOT, MARE) und medizinische Studien (Neuromayer). Die Pinguinkolonie erhielt in dieser Saison besondere Aufmerksamkeit: neben SPOT und MARE studierte IDEP das Verhalten der Tiere bei Drohnenüberflügen. Dadurch können in Zukunft Richtlinien für autonome Fluggeräte auf wissenschaftlicher Basis verfasst werden. Auch das wissenschaftliche Gewächshaus EDEN ISS entwickelt sich zu einem Langzeitprojekt und wurde gewartet (Kapitel 4.12). Ebenfalls neu hinzugekommen ist die langfristige Messung der Schmelzraten unter dem Ekström-Schelfeis (MIMO-EIS, Kapitel 4.15).

In der zweiten Saisonhälfte fand eine wissenschaftliche Expedition in die Kottas-Berge statt. Die Traverse führte drei wissenschaftliche Projekte über isostatische Hebung, Schneeakkumulation und Mumiyoablagerungen von Schneesturmvögeln (DML-GIA, Kottaspegel und Mumiyo-2, Kapitel 4.18, 4.9 und 4.17) sowie die Wartung der Seismometerstationen des geophysikalischen Observatoriums durch.

Andere biologische Studien am *Dallmann Labor* und auf der *SA Aghulas* analysierten die Ökologie und die Auswirkungen des menschlichem Einflusses auf Vögel, Algen und Rossrobben (Kapitel 6.1, 6.2 und 8.1). Abschließend wurde mittels Radarmessungen an *Dome C* nach einer zukünftigen Bohrstelle für Eiskerne gesucht (Beyond EPICA, Kapitel 8.2).

SUMMARY

The summer season in Antarctica is the short time between November and February, and the only time window when the harsh climate allows access via plane and ship. During the polar day there are enough days with warm and mild weather to allow major outside work (details in chapter 2 Weather conditions). But the available time for scientific and logistic operations is limited and both run in parallel, interfering with each other. This requires careful coordination and mutual consideration between scientists, technicians and logistics regarding the available resources. In this issue we report on the AWI's activities at *Neumayer Station III*, *Dallmann Laboratory* and other stations and research platforms in Antarctica.

During the austral summer season ANT-Land 2019/20 we supported 23 different projects at *Neumayer Station III*, *Dallmann Laboratory* as well as a campaign at *Dome C* and a participant on an *SA Aghulhas II* project. This season, we had neither campaigns at *Kohnen Station* nor flight campaigns. Some of the projects have related objectives but most have nothing in common. They belong to different disciplines, take place at different locations, run parallel to each other, overlap, have different length and logistical requirements. Whenever possible, different scientific projects and logistical operations are combined to minimize environmental impact, personnel demands and financial load. This means, that some projects are completely carried out by independent personnel, maintenance for other projects is adopted or different projects share personnel - scientific and technical. The main logistical milestones and station operations at *Neumayer Station III* are described in detail in chapter 3.

The season at *Neumayer Station III* is a colourful mixture of observatory maintenance, long running projects, winterers handover, station operations, media visits and additional projects. Chapters 4.1 to 4.3 describe the yearly observatory maintenance. This season the air chemistry observatory was accompanied by the related project VACCINE (chapters 4.11). Chapters 4.4 to 4.14 are about long running projects with various targets, e.g. sea ice (AFIN), marine life (PALAOA, SPOT, MARE) and medical questions (Neuromayer). The penguin colony received high attention this season: not only SPOT and MARE studied the colony, but also IDEP analysed penguin behaviour during drone flights (chapter 4.16). As a result, future guidelines for autonomous aircrafts can base on scientific studies. The scientific greenhouse EDEN ISS is developing into a long-term project and received the yearly maintenance (Chapter 4.12). Another long-term observation has started: the measurement of basal melt rates of the Ekström Ice Shelf (MIMO-EIS, Chapter 4.15).

During the second half of the season a scientific traverse travelled to Kottas Mountains. The traverse conducted three scientific projects about isostatic uplift, snow accumulation and snow petrel deposits (DML-GIA, Kottaspegel and Mumiyo-2, chapters 4.18, 4.9 and 4.17) as well as maintaining the seismometer stations of the geophysical observatory.

Other biological studies analysed ecology and effects of human impact birds, algae and Ross seals at *Dallmann Laboratory* and with *SA Aghulas II* (chapters 6.1, 6.2 and 8.1).

And finally, a glaciological radar project searched for a future ice core drilling site at *Dome C* (Beyond EPICA, chapter 8.2).

2. WEATHER CONDITIONS DURING ANT-LAND 2019/20 AT NEUMAYER STATION III

H. Schmithüsen[1] (not in field)

[1]AWI

The overall weather situation at *Neumayer Station III* during ANT-Land 2019/20 was mostly normal in terms of the basic meteorological parameters listed in Table 2.1. Concerning temperature, air pressure, wind speed, and the frequency of white-out, the monthly averages for the months November 2019 to February 2020 are within two standard deviations of the long-term averages, with one exception.

The November average surface pressure reached an all-time high of 994.2 hPa, which is 2.96 hPa higher than the old November record from 2016 of 991.2 hPa. This exceptionally high surface pressure is mainly due to a strong and persistent high pressure influence during the second half of the month. It goes along with comparably calm winds, and hence rather infrequent reported cases of white-out.

The temperature during the first three months of the season was well above the long-term mean (0.7°C, 1.3°C and 1.2°C). In contrast, February 2020 recordings are close to the mean value. Coldest temperatures were reached in November (Fig. 2.1), while December and January frequently show temperatures up to the freezing point.

In contrast to the rather calm November, December experienced windier conditions than normal. January and February were, which is typical, the calmer months in terms of wind speed. Also, with only 5 % and 6 % of observed White-Out the year 2020 started with fairly good working conditions. In 2020 there was only one, rather short, storm event on 18 and 19 January (Fig. 2.1).

Table 2.1: Monthly averages of meteorological parameters at *Neumayer Station III.* In parentheses are the long-term mean values for the time since 1981 (1992 for White-Out), together with the standard deviation. All values are calculated from the 3 hourly synoptic observations. Note that at UTC white-out is not observed, which biases the frequency of occurrence to too low values.

	Temperature	**Pressure**	**Wind speed**	**White-out**
November 2019	**-9.1°C**	**994.2 hPa**	**8.0 m/s**	**19 %**
	(-9.8 ± 1.5)°C	(984.8 ± 4.4) hPa	(9.4 ± 1.6) m/s	(24 ± 12)%
December 2019	**-3.5°C**	**994.3 hPa**	**9.6 m/s**	**17 %**
	(-4.8 ± 0.9)°C	(987.7 ± 5.5) hPa	(7.2 ± 1.5) m/s	(17± 11)%
January 2020	**-2.9°C**	**990.3 hPa**	**5.8 m/s**	**5 %**
	(-4.1 ± 1.0)°C	(989.4 ± 3.9) hPa	(6.6 ± 1.2) m/s	(13± 8)%
February 2020	**-8.2°C**	**988.5 hPa**	**7.2 m/s**	**6 %**
	(-8.1 ± 1.5)°C	(987.1 ± 3.7) hPa	(7.5 ± 1.5) m/s	(14±9)%

During ANT-Land 2019/20 there was one event of significant and persistent snow accumulation around November 12 (Fig. 2.1). During the first half of December there was also reasonably frequent snowfall reported, but in combination with rather strong winds which prevented the snow from accumulating. After this period the snowpack was predominantly subject to sublimation and compaction, which lowered the snow level from December 15 to the end of the season by more than 10 cm.

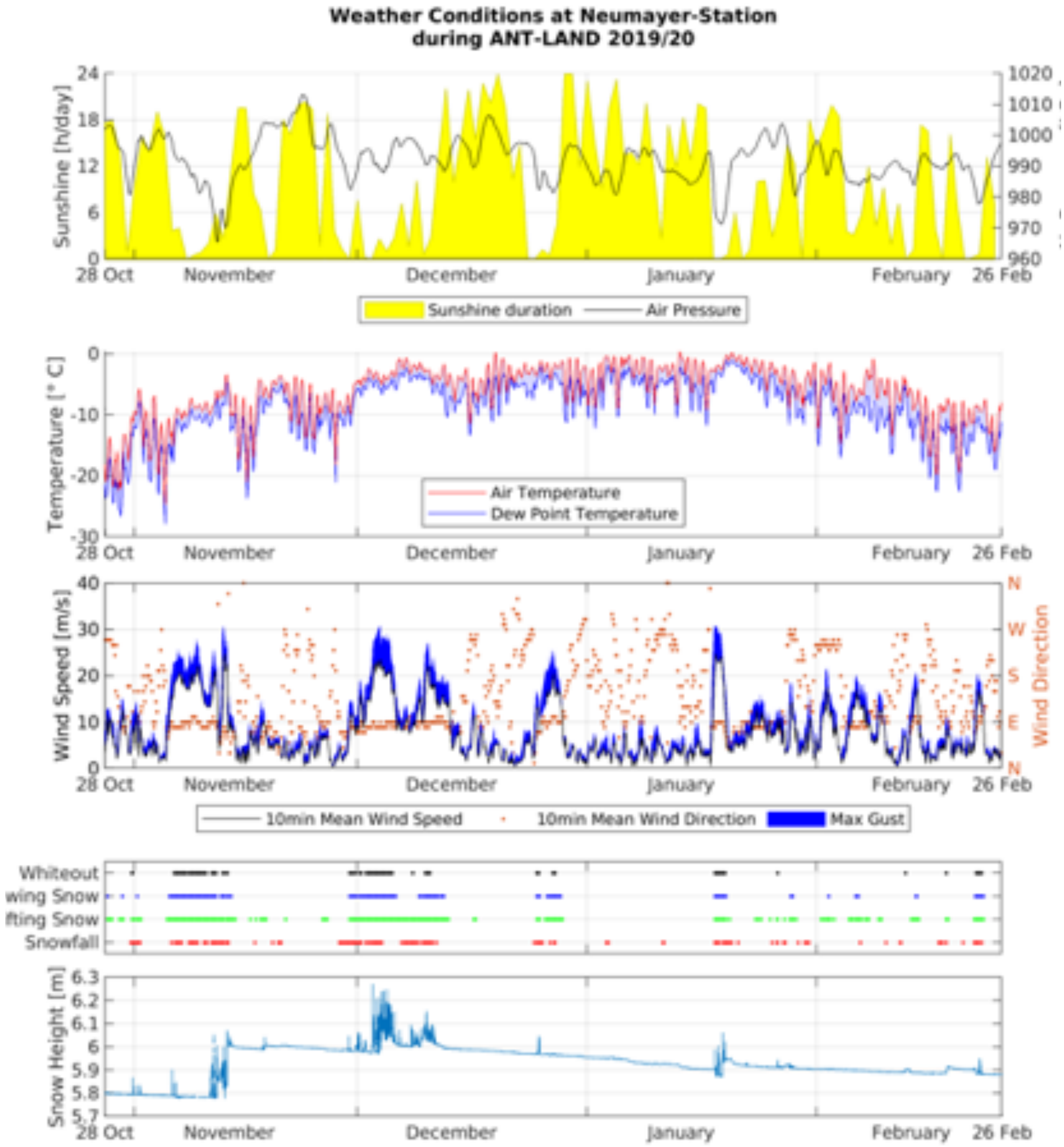

Fig. 2.1: Weather conditions at Neumayer Station III during ANT-Land 2019/20

3. STATION OPERATIONS

Christine Wesche[1], Thomas Matz[1]   [1]AWI

During ANT-Land 2019/20 summer season, the year-round station *Neumayer Station III* was the logistical base for several scientific and technical/logistical summer projects.

The personnel movement and some of the cargo transportation was done using the Dronning Maud Land Air Network (DROMLAN). DROMLAN is a merger of 11 national Antarctic Programmes sharing logistics to transport personnel and cargo in an economic way to and within Antarctica. This season 13 intercontinental flights to Novo Runway and nine flights to Troll Airfield were scheduled between the 29.10.2019 and 26.02.2020. The intracontinental transportation was performed by ski-equipped Basler BT-67 aircraft. AWI moved 50 PAX into and out of Antarctica. The cargo on both legs sums up to about 10 t. All PAXs final destination in Antarctica was *Neumayer Station III* as *Kohnen Station* was closed in season 2019/20.

The official end of the 39. wintering is marked with the first arrival of summer guest on 05.11.2019. Together with the technicians for the routinely maintenance work and housekeeping, two scientific projects started right in the beginning of the season, although immediately after the arrival of the first summer guests, a severe 10 days long storm hampered all outdoors activities.

The 40. wintering team arrived on 21.12.2020 at *Neumayer Station III* and the handover period started immediately. The official station handover was celebrated on 18.01.2020.

Due to the absence of *Polarstern* in season 2019/20, the supply of the station was organized in strong collaboration with the South African National Antarctic Programme (SANAP). The supply and discharge of *Neumayer Station III* was performed in three ship calls at Atka Bay by *SA Agulhas II*. The first ship call took place on 31.12.2019/01.01.2020, where most of the supplies (incl. fuel) had been delivered and the first return freight was loaded onto the ship. A second ship call at Atka Bay took place on 03.02.2020, where the remaining cargo and fuel was delivered. The main discharge of the station was performed on the 15.02.2020 during the third call of *SA Agulhas II* at Atka Bay.

The Swedish Antarctic Programme requested help with the disposal of waste from WASA station. An overland traverse between *Neumayer Station III* and WASA station started on 02.01.2020 to pull empty containers and some freight to the Swedish station. On the way back, the containers were filled with waste, which was delivered to *SA Agulhas II* on the third ship call.

A media team around the ARD correspondent of South America visited the station in the beginning of the season for 10 days. A second media team of the ZDF series “TerraX – Faszination Erde” visited *Neumayer Station III* in January 2020 to record material for the 100. issue of the series. During the whole season, the presence of *Neumayer Station III* on German media was very good.

The continuous observation of the sea ice, using radar satellite imagery of the Sentinel-1a/b satellites, enables safe operations on the fast ice in the Atka Bay. Changes at the northern boundary of the ice usually marks the time, when the sea ice should be closed for access. First indications of a sea ice break up were found on 08.01.2020, which resulted in a closure of the sea ice. The bay broke off completely on 09.02.2020, but due to mainly easterly winds, some of the now two-year sea ice floes stayed close to the western boundary of Atka Bay.

High resolution satellite images were also used to find new routes, e.g. onto the Atka Ice Rise (southern boundary of Atka Bay) to deploy seismometer or a shorter route to Fostefjell to maintain the seismometer and deploy a permanent GPS receiver.

The successful summer season 2019/20 ended with the departure of the last summer guests on 25.02.2020. This is also marked as the official start of the 40. wintering.

3.1 Technical operations

Christine Wesche[1], Thomas Matz[1]   [1]AWI

Introduction

Preparatory works had been performed by the overwintering team already before the first summer guest arrived at the station. Some storage containers from the winter camp on the coast were transported to *Neumayer Station III* to be made available for summer works. The 1,500 m long landing strip, which is made of snow, was reconstructed by the technicians of the wintering team, to welcome the first intracontinental flights in late October 2019. To guarantee safe landings of arriving aircraft, the landing strip was groomed especially after heavy storms and the flags were controlled.

Early in November 2019, the technical summer staff arrived to maintain the stations. The summer staff was heavily involved in all ship discharge operations and performed the container stowage work.

During all summer seasons, routine works, maintenance jobs at the building and the technical devices as well as the important technical tests of function and security of facilities and building had to be performed.

In connection with the future refurbishment of the energy supply of the station by using renewable wind and solar energy, the mounting and implementing of a photovoltaics test device with a special data entry function was planned at the frontage of the building. In the outdoor area, the wooden top layer at deck 0 should be partly renewed. Both projects could not be performed due to unfavourable weather conditions and an extensive amount of work, but they will be integrated in the summer season plans for 2020/21.

Preparation and performance of the scientific traverses of the geophysicists and meteorologists to the external observatories installed on Halvarryggen and Søråsen were supported by technical personnel.

Station maintenance works and repairs

After a severe storm, the 23rd station elevation started on 14.11.19 and was finished after ten days. As the station has to be lifted twice within a summer season, the 24th station elevation started on 07.12.2019 and was completed on 19.12.2019.

The station hydraulics (cylinders of the bipods, side skirts, pipe installations and hydraulic hoses) were comprehensively maintained and inspected by an engineer of the relevant firm. Additionally, the hydraulics engineer controlled the technical device components at the hydraulic container as well as the control system with its plug connections. To improve the recording of sporadically returning system failures, a monitoring module was installed at the BUS system.

The replacement of the obsolete hard- and software of the steering computer, together with other works on the hydraulic system, is planned for the season 2020/21.

In co-operation with an engineer from the producer, the defect resp. worn sectional gates of the balloon filling hall at the roof of the station were replaced by new pressure-sealed gates. The new two-winged gates are hydraulically powered. Both wings can be steered individually by means of a foot-operated switch.

Both station entrance doors, south and west, were substituted by new doors with multiple locking devices. The old doors did not tighten any longer, allowing drifting snow to get in.

Additional routine maintenance works were performed, e.g. with the elevator, cleaning of snow melting facility, air conditioning plant, wastewater treating plant, and other devices.

Station technique

- Cogeneration Plant

Regular maintenance was carried out according to the engine running times. Due to problems in the cooling water circuit of the Power Unit #1 caused two blackouts. Regularly, the emergency diesel and the USV plant ensured power supply until the standby Power Unit #2 took over. Automatically, Power Unit #3 then turned into standby function. After the arrival of the needed spare part, an exhaust valve, Power Unit #1 could be repaired, and the device could be re-started without difficulty.

- Wind turbine

The wind energy plant was elevated for 2 m and maintained. In February, the mechanical fixing brake caused problems, it could not be released, and the plant switched into a disturbance mode. The brake could be repaired so that the wind energy plant could be reset into function.

- Air conditioning

The ventilation systems were maintained according to plan and the filter cartridges were exchanged. In some rooms on deck 2, the extraction of air was re-adjusted. Because of steering problems at the devices 100/200 and 300/301, a software update was installed in co-operation with the specialized firm in charge.

- Wastewater plant and sanitary system

On the wastewater plant, the routine maintenance and inspection work (regular withdrawal of excess sludge, control and rinsing and cleaning of the grease trap) was performed. The sewage lifting unit at the tween deck was replaced after roundabout ten years of duty by a new reserve unit because of heavy wear at the case in the area of the pumps. A new reserve system must be provided. The waste water pipe leading to the ice field from the vehicle shed was controlled, especially the accompanying heating system.

Miscellaneous station technique

Regular work during the season covered the levelling of the station and controlling of the level system of the bipods.

The outside spotlights for deck 0 and in the section of deck 3 of the balloon filling hall were replaced by LED spotlights with more luminance and less consumption.

The sterilizer at the hospital was renewed and put into operation.

- IT and communication

New hardware for the radio beacon at the trace element observatory installed, as well as a new sender and repeater at *Neumayer Station III*. The roof antenna was repaired.

The old INMARSAT unit "Fleet 77" was dismantled, as is was no longer needed as a redundancy for the satellite link.

Two new installations were done: (i) the installation and setup of the ground station „Oscar 100" and (ii) the installation and implementing of the receiver Flightradar 24. *Neumayer Station III* is one out of two stations in Dronning Maud Land, that is now equipped with an ADS-B receiver for flight tracking.

For the new sterilizer at the hospital, a PC and software were installed.

A hardware upgrade of the telecommunication system was done by changing the provider.

- Safety technology

After a long time of duty, the complete fire alarm system was renewed according to plan. This had become necessary because the existing technique was obsolete and replaced by follow-up models. The renewal comprises all smoke and fire detectors on all decks and in all rooms, the central fire alarm box at the radio operator's office and the extensions of the center on the different station decks. The renewal could be performed in co-operation with a Siemens engineer, another expert and support of the technical team.

The total supply of fire extinguishers at the station, the external observatories and inside the vehicle fleet was routine exchanged.

- Checking electrical devices

All movable electrical devices have been tested by a specialist in according to DGUV V3, around 1200 pieces.

Scientific/technical outdoor facilities

The air chemistry observatory, the greenhouse EDEN and the Radom (satellite link) were routine elevated. The measuring fields of the infrasound array could also be elevated between 20. and 29.12.19 without any technical problems.

The exit shafts at the magnetic observatory and at the balloon trench were elevated. Moreover, at the magnetic observatory the wooden ceiling and the ice walls were treated.

The antenna field of the WSPR-radio beacon at the air chemistry observatory was elevated, as well as the „library in the ice".

Vehicle engineering

- Boom Lift

A new telescope working platform was delivered by *SA Agulhas II*, leg 1, on it's call between 31.12.19 and 02.01.20.

After the construction of *Neumayer Station III* in 2009, the old vehicle was taken over by the construction firm. With more than twenty years of age, and with defects that could not be repaired on site, it was exchanged and loaded on the supply ship to be returned. Moreover, the vehicle did not come up to actual safety requirements.

At the station, the telescope working platform is used for control works at the frontage, also in the vehicle shed and for external buildings as the wind energy plant.

- Pistenbullys

Besides numerous maintenance and repair works on all Pistenbully vehicles, also substancial works on the „300 type“ Polar vehicles, which had been planned in advance, were performed. Those are Pistenbully vehicles that have been used for more than ten years for traverses to *Kohnen Station* and beyond into the Antarctic inland ice. The repair works on the vehicles PB25, PB26, PB29, PB31 and PB34 each took one week or a little longer. In this connection, tracks were dismounted and vehicles were jacked up on two heavy duty sledges. Among other things, chassis were controlled resp. refitted. Coolant hoses, hydraulic hoses in high pressure and working pressure range, cooling water, motor oil and hydraulic oil were exchanged. The works were performed by a Käßbohrer service technician and a technician from RFL.

The PB21 vehicle which had been sent to a general overhaul by the manufacturer Käßbohrer in 2019 and was delivered to *Neumayer Station III* with the 2nd ship call in early February 2020. The station vehicle is equipped with a radio controlled crane and by mounting a basket, this crane can also be used for works in great height and is therefore a additional device for this kind of work, that can, however, also be used as a normal Pistenbully for snow shovelling as well as a drawing vehicle for heavy duty sledges.

Snow mobiles and Nansen sledges

The snow mobiles were serviced according to the specifications of the manufacturer, and repairs were performed. In each summer season, up to three vehicles will be shifted to the AWI harbour warehouse in Bremerhaven for general overhaul, and refitted vehicles will be returned to the station.

Various repairs, especially smaller wood and welding works, were performed with the Nansen sledges to keep them ready for use. In case of extensive damages, the sledges are exchanged. Heavily damaged sledges are generally repaired by the manufacturer in Germany.

Arctic trucks with trailer

Both Arctic trucks were serviced and it is planned to have this maintenance work done directly at *Neumayer Station III* in the future.

The vehicle trailers were rebuilt from tracks to wheels which are identical with the Arctic truck wheels. First experiences, as to the use on longer traverses could be gained on an expedition to the Kottas mountains.

Heavy duty sledges for 20 feet containers and general cargo

All preventive maintenance works were carried out on the heavy duty sledges in accordance with the manufacturer.

SANAP Summer Station (SSS)

The SSS, situated 6 km north from *Neumayer Station III*, is used by the South African National Antarctic Programme (SANAP) as a base for their ship unloading operations at Atka Bay during summer. During the winter months it can be used by the *Neumayer Station III* overwintering team in case of emergency. In this season, the station was elevated and repaired by a South African team. AWI logistics supported the preparations and arranged transport of freight, vehicles and personnel from ship’s discharging point, about 14 km away, to SSS during all ship calls.

Before the start of the repair works by the South African technical team the area around SSS was levelled by means of Pistenbullys. Moreover, in the course of the repair works two crooked and defect support legs of the station were cleared by *Neumayer Station III* personnel so that South African technicians could re-install them. The South Africans could also repair the diesel generator and the hydraulic system of the station. By means of the hydraulic system and extended support legs, the station could be driven up, so that it now is now positioned clearly above the snow level.

3.2 General flight operations

Christine Wesche[1], Thomas Matz[1]   [1]AWI

All flight movements around *Neumayer Station III* are provided in Table 3.2.1.

Tab. 3.2.1: Flight movements at *Neumayer Station III* and Atka Bay during ANT-Land 2019/20

Date	UTC Time	Registration	Start	Destination
02.11.2019	1913	N131PR	Rothera	Neumayer
03.11.2019	1223	N131PR	Neumayer	Wolfsfang RW
05.11.2019	1804	C-GKKB	Novo	Neumayer
	1919	C-GKKB	Neumayer	Novo
15.11.2019	1226	C-GEAI	Novo	Neumayer
	1317	C-GEAI	Neumayer	Novo
	1750	C-GOOU	Rothera	Neumayer
	1913	C-GOOU	Neumayer	Wolfsfang RWY
17.11.2019	1253	N131PR	Penguin Butka	Neumayer
	1837	N131PR	Neumayer	Penguin Butka
21.11.2019	1044	N131PR	Penguin Butka	Neumayer
	1648	N131PR	Neumayer	Sanae IV
22.11.2019	1037	C-GOOU	Wolfs Fang RWY	Neumayer
	1338	C-GOOU	Neumayer	Penguin Butka
23.11.2019	1220	C-GOOU	Whichaway Skiway	Neumayer
	1619	C-GOOU	Neumayer	Penguin Butka
27.11.2019	1157	C-GOOU	Wolfs Fang RWY	Neumayer
	1227	C-GKKB	Novo	Neumayer
	1344	C-GKKB	Neumayer	Novo
12.12.2019	1723	C-GEAI	Novo	Neumayer
12.12.2019	1917	C-GEAI	Neumayer	Novo
14.12.2019	1239	C-GOOU	Penguin Butka	Atka Bay
14.12.2019	1651	C-GOOU	Atka Bay	Penguin Butka
16.12.2019	1302	C-GOOU	Penguin Butka	Atka Runway
	1611	C-GKKB	Neumayer	Penguin Butka
22.12.2019	1603	N131PR	Penguin Butka	Atka Runway
	1622	C-GEAI	Novo	Neumayer
	1630	C-GKKB	Novo	Neumayer
	1802	N131PR	Atka Runway	Penguin Butka

Date	UTC Time	Registration	Start	Destination
	1915	C-GKKB	Neumayer	Novo
23.12.2019	1022	HND	Sanae IV	SANAP Summerstation
	1333	HND	Neumayer	Sanae IV
	1627	C-GEAI	Neumayer	Aboa
	2210	C_GEAI	Aboa	Neumayer
24.12.2019	1626	C-GEAI	Neumayer	Aboa
	0915	N131PR	Atka Runway	Penguin Butka
	1137	C-GOOU	Penguin Butka	Atka Runway
28.12.2019	1906	N131PR	Penguin Butka	Atka Runway
	1945	N131PR	Atka Runway	Penguin Butka
30.12.2019	1028	C-GOOU	Whichaway Skiway	Atka Runway
	1346	C-GOOU	Atka Runway	Penguin Butka
09.01.2020	1026	ZS-HND	Sanae IV	Neumayer
	1049	ZS-HND	Neumayer	SANAP Summerstation
	1057	ZS-NHD	SANAP Summerstation	Sanae IV
10.01.2020	1302	C-GOOU	Penguin Butka	Atka Runway
	1620	C-GOOU	Atka Runway	Penguin Butka
11.01.2020	1231	N131PR	Whichaway Skiway	Atka Runway
	1515	N131PR	Atka Runway	Penguin Butka
14.01.2020	2101	C-GEAI	Novo	Neumayer
	2113	C-GKKB	Novo	Neumayer
	2200	C-GEAI	Neumayer	Sanae IV
	2227	C_GKKB	Neumayer	Aboa
15.01.2020	1331	ZS-HNC	Sanae IV	SANAP Summerstation
	1436	ZS-HNC	SANAP Summerstation	Neumayer
	1437	ZS-HND	Sanae IV	Neumayer
	1557	ZS-HNC	Neumayer	Sanae IV
	1559	ZS-HNC	Neumayer	Sanae IV
16.01.2020	1055	N-131PR	Penguin Bukta	Atka Bay
	1215	C-GOOU	Penguin Bukta	Atka Bay
	1252	N-131PR	Atka Bay	Penguin Bukta
	1517	N-131PR	Penguin Bukta	Atka Bay
	1559	C-GOOU	Atka Bay	Penguin Bukta
	1721	N-131PR	Atka Bay	Penguin Bukta
23.01.2020	1128	N-131PR	Penguin Bukta	Neumayer
24.01.2020	0922	N-131PR	Neumayer	Wasa / Aboa
27.01.2020	1748	N131PR	Penguin Bukta	Neumayer
	1758	N131PR	Neumayer	Troll
28.01.2020	0916	C-GKKB	Novo	Neumayer
	0951	C-GKKB	Neumayer	Novo
	1104	ZS-HND	Sanae IV	Neumayer
	1210	ZS-HND	Neumayer	Sanae IV

Date	UTC Time	Registration	Start	Destination
	1921	C-GOOU	Wolf’s Fang	Neumayer
	2102	C-GOOU	Neumayer	Troll
01.02.2020	1055	ZS-HND	Sanae IV	SANAP Summerstation
	1105	ZS-HND	SANAP Summerstation	Neumayer
	1134	ZS-HND	Neumayer	Sanae IV
	1147	ZS-HND	Sanae IV	SANAP Summerstation
	1155	ZS-HND	SANAP Summerstation	Neumayer
	1252	ZS-HND	Neumayer	Sanae IV
03.02.2020	1046	ZS-HND	Sanae IV	SANAP Summerstation
	1121	ZS-HND	SANAP Summerstation	SA Agulhas II
	1250	ZS-HND	SA Agulhas II	Sanae IV
15.02.2020	1550	ZS-HND	Sanae IV	SANAP Summerstation
	1552	ZS-HND	SANAP Summerstation	SA Agulhas II
19.02.2020	1036	C-GEAI	Novo	Neumayer
	1118	C-GEAI	Neumayer	Novo
	1822	C-GEAI	Novo	Neumayer
23.02.2020	1524	C-GOOU	Wolf’ Fang	Neumayer
	1527	N131PR	Wolf’s Fang	Neumayer
24.02.2020	1459	C-GOOU	Neumayer	Rothera
	1502	N131PR	Neumayer	Rothera
	1540	C-GEAI	Neumayer	Neumayer
	1639	C-GEAI	Neumayer	Neumayer
25.02.2020	0526	C-GEAI	Neumayer	Novo
	1328	C-GEAI	Novo	Neumayer
	1423	C-GKKB	Novo	Neumayer
26.02.2020	0456	C-GEAI	Neumayer	Rothera
	0504	C-GKKB	Neumayer	Rothera

At the beginning and the end of the season, *Neumayer Station III* serves as a gateway into central Dronning Maud Land, as all ski-equipped aircraft landed at the 1,500m x 40 m landing strip on their way to their final destinations Wolf’s Fang and Novo Runway and back to Rothera Station.

Contrary to the last seasons, no flight weather forecaster was based at *Neumayer Station III.* The forecaster was situated at the Aviation Office at Antarctic Logistics Center International (ALCI) in Cape Town. The beginning of the season was covered by Christian Paulmann, who was replaced by Michael Knobelsdorf for the main part of the season. The last part of the season was done by Tobias Schaaf, who was trained for three weeks by Christian Paulmann in Cape Town. The weather briefing covered the forecasts for overall 22 intercontinental flights, that were conducted within the DROMLAN area, all intracontinental flights and land traverses conducted by AWI.

3.3 Ship operations

Christine Wesche[1], Thomas Matz[1]

[1]AWI

Due to the absence of *Polarstern*, the station supply was conducted by *SA Agulhas II*. In total three ship calls at Atka Bay were performed, starting with the first between 31.12.2019 and 02.01.2020. During the offloading and fuel bunkering 11 freight and three reefer containers, 244’000 L arctic diesel and 54’000 L Jet-A1 were delivered, together with some freight for the Swedish and Finnish Antarctic Programmes. AWI loaded eight return freight containers and an end-of-life vehicle onto the ship for northbound transportation.

The second ship call was performed in only one day on 03.02.2020. AWI received one freight and one reefer container and one Pistenbully. Another 120’000 L arctic diesel and 15’000 L Jet-A1 were bunkered.

All of the remaining return freight including the Swedish waste containers and vehicles, were delivered to the ship on the third call of SA Agulhas II at Atka Bay on 15.02.2020. AWI discharged three freight, two waste and four reefer containers.

During all ship operations, the northern pier was used. The sea ice conditions were favourable and the conditions of the ice shelf were also optimal.

4. NEUMAYER-STATION III

4.1 The Air Chemistry Observatory Neumayer

Rolf Weller[1], Julia Loftfield[1],
Marcus Schuhmacher[1], Silvia Henning[2]

[1]AWI
[2]TROPOS Leipzig

Objectives

The atmosphere above Antarctica is the cleanest part of the Earth's troposphere and can be employed as a large clean air laboratory to study natural conditions comparable to atmospheric processes prevailed elsewhere in preindustrial times. Therefore, Antarctica offers an outstanding place to study the background composition and the natural biogeochemical cycling of aerosol. Nowadays, minor anthropogenic emissions arising from fossil fuel combustion during research and tourism activities may be considered as well.

The main task of the *Air Chemistry Observatory Neumayer* is to provide continuous, year-round data records for important gaseous and particulate trace components of the coastal Antarctic troposphere. Such long-term atmospheric observations are mandatory to understand the present Southern Ocean climate system and identify its major drivers. Another aspect of studying atmospheric chemistry in Antarctica is the need to interpret records of archived trace compounds in ice cores. Provided the present atmospheric chemistry and the physical-chemical processes of air to snow transfer are well characterized, we can use such records to derive information about climate, composition and chemistry of the paleo-atmosphere. The *Air Chemistry Observatory Neumayer* is one of only very few comparable clean air laboratories operated in Antarctica partly established since 1983. There is a strong scientific cooperation with the meteorological observatory. Both observatories are part of the GAW (Global Atmosphere Watch) global station network. On site, one person of the wintering team (n = 9), usually an air-chemist or meteorologist is responsible for the observatory.

Fieldwork

Concerning atmospheric chemistry, the project VACCINE (***V**ariation in **A**ntarctic cloud condensation nuclei (**CC**N) and ice nucleating particle (**IN**P) concentrations at **Ne**umayer Station*) managed by the Institute for Tropospheric Research (TROPOS, Leipzig. PI: Silvia Henning) in cooperation with the AWI started in December 2019. Silvia Henning installed a Cloud Condensation Nuclei (CCN) counter in the *Air Chemistry Observatory Neumayer*. We aim at extending the existing aerosol measurements at *Neumayer Station III* by *in-situ* CCN and ice nucleating particles measurements. We will link these data with regional meteorology and the chemical composition of the sampled aerosol particles for identifying sources of INP and CCN. The scientific background of this project addresses the fact that Polar Regions have a strong global impact on climate conditions but the crucial aerosol – cloud – climate interaction is poorly understood, especially in the Southern Ocean realm.

Finally, the operation of the observatory was taken over by the new air chemistry over-winterer Julia Loftfield.

Preliminary (expected) results

We completed an *in-depth* evaluation and validation of the established long-term observations (LTO) in February/March 2020, except the chemical analyses of the aerosol filter samples. Like in previous years, the outcome of this subsequent analysis revealed the high quality of the measured time series comprising

- condensation particle concentration (CPC)
- aerosol size distribution
- black carbon concentration (BC)
- aerosol scattering coefficients
- surface ozone concentration

with generally negligible data gaps, occasionally caused by short temporary instrumental problems or routine service operations. As an example, the particle size distribution measured by an optical particle counter (OPC) in the range between 90 nm and 5 µm throughout the year 2019 is shown in Fig. 4.1.1. Put in a nutshell, austral summer is dominated by higher total aerosol number concentrations with mean particle diameters around 100 nm (mainly biogenic sulphur aerosol, i.e. non sea salt sulphate and methanesulphonate), while during polar night, very often larger particles (predominantly sea salt aerosol) between 200 nm and 2 µm, but lower total number concentrations are typical.

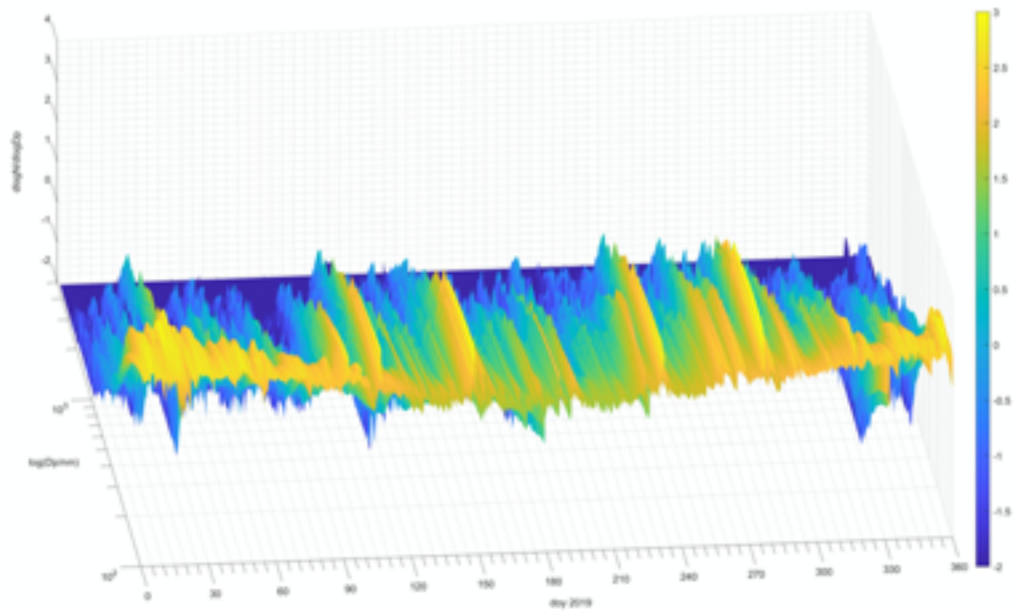

Fig. 4.1.1: 3D contour plot of the particle size distribution dN/dlogDp (cm^{-3}) with a dlogN/dlogDp (cm^{-3}) scale as z-axis (logarithmic colour scale to the right), based on OPC data recorded with 64 channel resolution. Presented data are one-hour averages based on the originally size distribution spectra taken in 10-minute intervals; doy is day of the year 2019.

The size distribution determines the fraction of the aerosol which can potentially act as cloud condensation nuclei at a given atmospheric water vapor super saturation. On the other hand, aerosol optical properties and the direct effect of aerosol on radiation forcing is determined by its refractive index (RI), size distribution and shape. From our data, we could now determine RI of the aerosol at *Neumayer Station III* for the whole year 2017, presented in Fig. 4.1.2. To conclude, we found largely constant RI values throughout the year without any sign of seasonality. Therefore, it seems reasonable to use a single, constant RI value of 1.44 for modeling optical properties of natural, coastal Antarctic sub-µm aerosol (Jurányi and Weller, 2019).

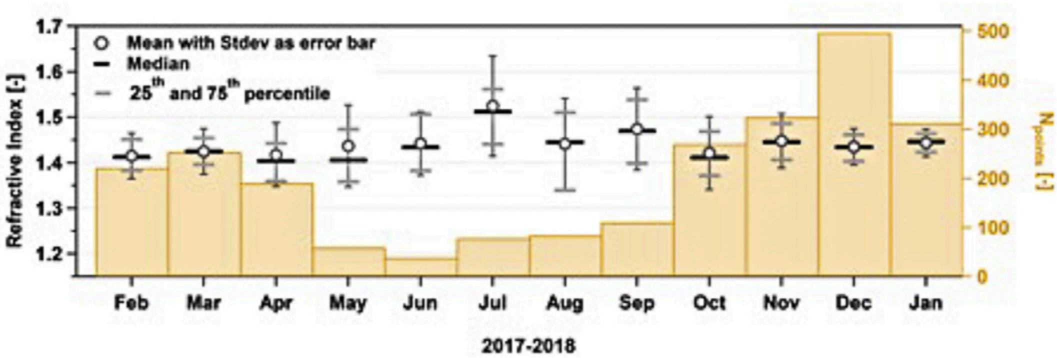

Fig. 4.1.2: The monthly averages (with error bars as the standard deviation), medians and percentiles of RI from the coastal Antarctica, measured at λ= 633 nm for dry aerosol particles. The orange bars refer to the right axis and show the number of successful RI retrievals in the corresponding month.

Data management

In the meanwhile, we archived part of the long-term observations after thorough evaluation in the respecting repositories. As mentioned above, the chemical analysis of the aerosol filter samples is ongoing and will be finished during summer this year.

- PANGAEA: we will submit the complete data set after chemical analysis of the aerosol filter samples.
- GAW: http://ebas.nilu.no/default.aspx

References

Jurányi Z and Weller R (2019) One year of aerosol refractive index measurement from a coastal Antarctic site, Atmos. Chem. Phys. Discuss.,https://doi.org/10.5194/acp-2019-277, in review.

4.2 The Geophysical Observatory Neumayer

Tanja Fromm[1], Alfons Eckstaller[1] (not in field), Jölund Asseng[1] (not in field), Edith Korger[1], Josefine Stakemann[1], Noah Trumpik[1], Ina Wehner[1], Jürgen Matzka[2] (not in field)

[1]AWI
[2]GFZ

Objectives

The geophysical observatory at *Neumayer Station III* allows long term observations with different geophysical instruments and contributes to worldwide networks collecting geophysical data for the scientific community. The location at the edge of Antarctica makes the observatory a valuable data point for all networks with sparse data coverage in the southern hemisphere, especially in Antarctica. Distances between two comparable instruments easily become hundreds of kilometer. The closest stations with winter capacities are *SANAE IV* (230 km), *TROLL* (420 km) and *Novolazarevskaya* (750 km). In contrast to project datasets the observatory allows continuous, long time series revealing slow and small changes otherwise undetectable.

The observatory operates instruments covering following disciplines: a) seismology (Fromm et. al., 2018; Eckstaller, 2006), b) geomagnetism (GFZ, 2016) and c) GPS measurements.

a) Seismology

The primary objective of the seismographic observations at *Neumayer Station III* is to complement the worldwide network of seismographic monitoring stations in the southern hemisphere. Within Antarctica only eleven broad band seismometers provide data in real time, three of them are operated by AWI. Special interests focus on the detection of local and regional earthquakes within Antarctica. Recently, interest in seismological data from ice covered regions has drastically increased, as seismometers also record cryogenic events giving information about ice dynamic processes (e.g. Aster et al. 2017).

The local seismographic network at *Neumayer Station III* comprises the station VNA1 near *Neumayer Station III* itself and two remote stations VNA2 and VNA3 on the ice rises Halvfarryggen and Søråsen, resp. Additionally to the seismic broadband station VNA2 is completed by an small aperture array with 15 vertical seismometers placed on three concentric rings in a total diameter of almost 2 km. During the winter 2019, we extended the array with a fourth ring consisting of 7 autonomous broadband stations (VNAD1-7) in distances up to 30 km from VNA2 (see Fig. 4.2.1, inset). Other unattended seismographic broadband stations record data at logistically feasible locations (see Fig. 4.2.1).

b) Geomagnetism

The Geomagnetic Observatory at *Neumayer Station III* was built in 2009 and currently hosts a GSM-19 Overhauser proton-magnetometer for recording total intensity, two 3-component fluxgate sensors recording directional changes (FGE and STL) and high frequency induction coils for ionosphere research (MICA-S, see chapter 4.19). A simple all sky camera completes the instrumentation for geomagnetic research.

Since 2014 the observatory is a certified member of the Intermagnet organisation guaranteeing quality and standard specifications for measuring, recording and exchanging data. It is one of only nine Intermagnet observatories in Antarctica.

c) GPS recordings

We record continuous GPS since beginning of July 2012 with a dual-band Ashtec Z-12 receiver on the roof of *Neumayer Station III*. GPS data provide valuable information for higher atmospheric research and reveal characteristics of the Ekström Ice Shelf dynamics.

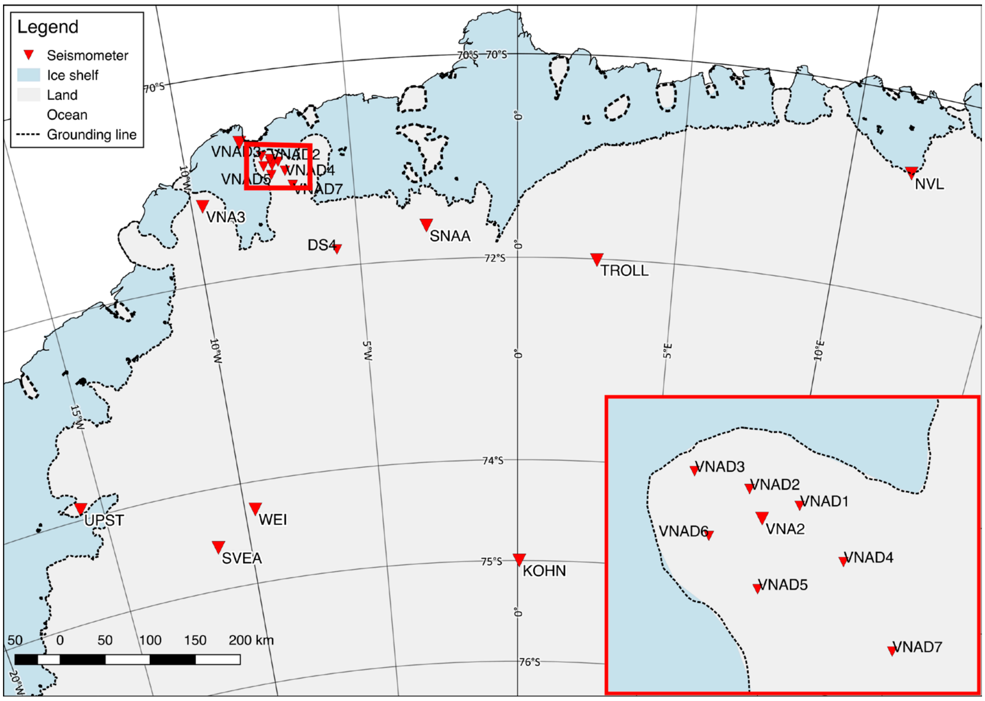

Fig. 4.2.1 Map showing the active seismometer stations in Dronning Maud Land of the AW network during 2019 and additional partner stations SNAA and TROLL. The red inset shows the location of the temporary seismometer installation around VNA2.

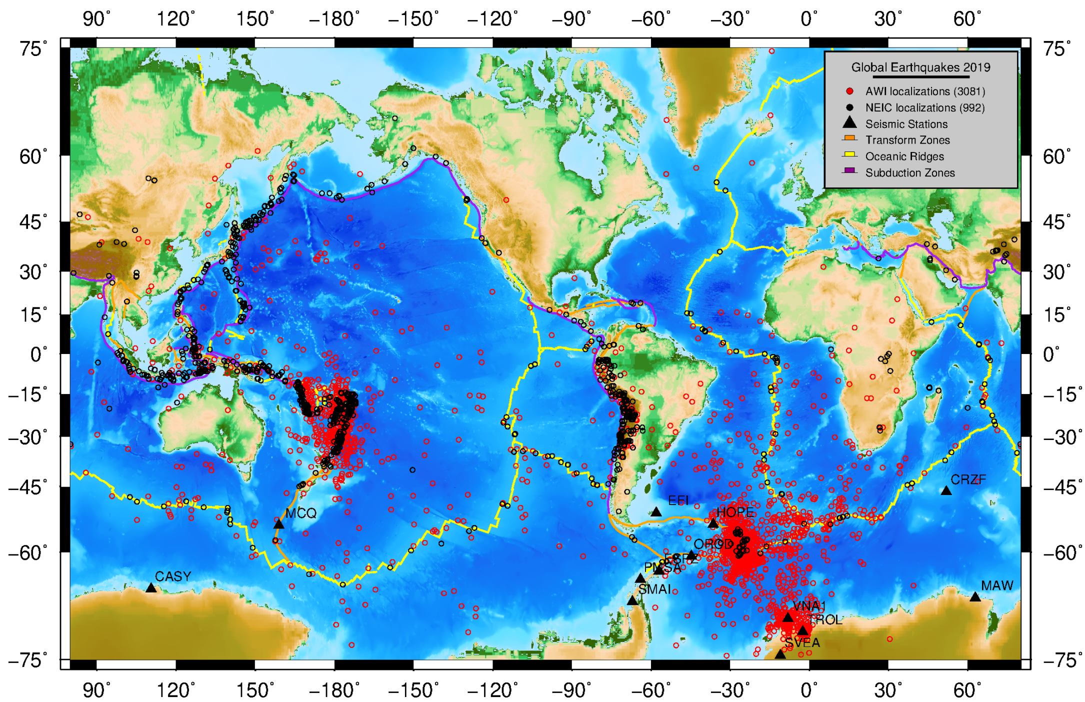

Fig. 4.2.2 Map showing seismic events recorded at the AWI network in 2019

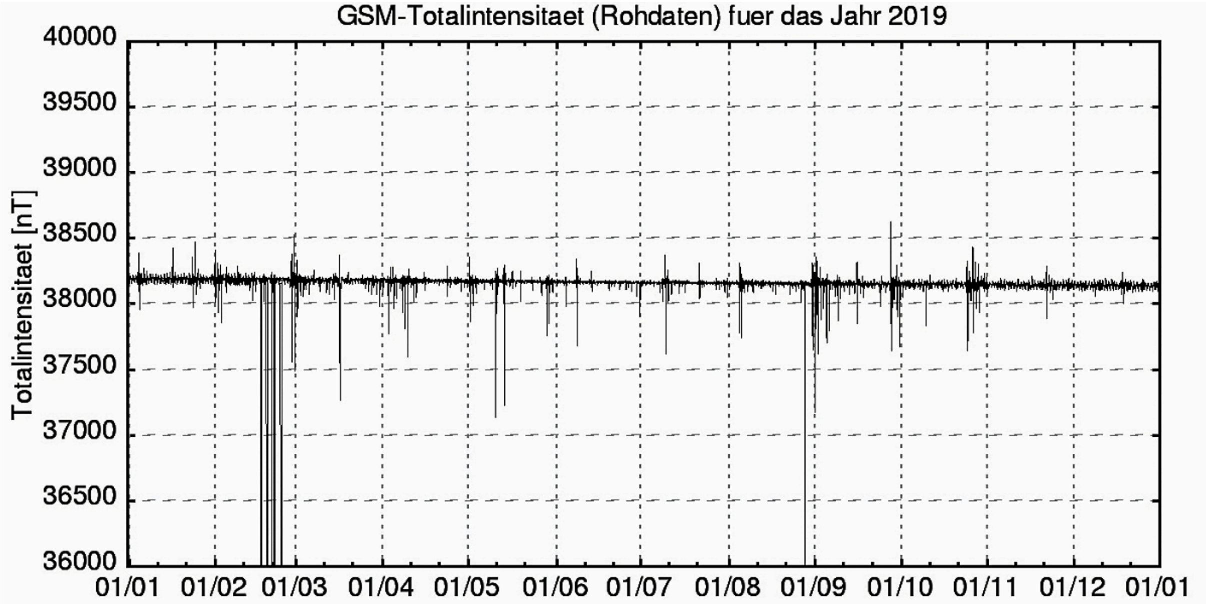

Fig. 4.2.3 Total Intensity of the geomagnetic field at Neumayer Station III, recorded by the Overhauser GSM-19

Fieldwork

During the Antarctic summer season 2019/2020 we serviced the seismometers VNA2 and VNA3 of the AW network via land based traverses. The seismometers and the instrument pits were set up at the new snow level, data downloaded, a quick quality check was performed, as well as necessary instrument upgrades done. Stations of the temporary installation VNAD have been dismantled and data retrieved for consecutive analysis. We setup a new temporary network east of *Neumayer Station III* for the year 2020 consisting of 12 stations.

The station NVL has been visited and data fetched for the year 2019. Our colleagues from project DML-GIA (chapter 4.18) serviced stations WEI, SVEA and DS4 during their field work. Stations KOHN and UPST were not serviced this season.

This season we conducted maintenance work in the underground ice cave hosting the seismometer and the magnetic observatory. Following the ice pressure, the walls deform and move inside the ice cavity. We removed ice from the walls to regain enough space around the instruments and added an ice tunnel to store the north seeking gyro within the observatory but with enough distance from the sensitive instruments. To correct instrument offsets we calibrated the gyro using sun observations and GPS measurements.

Preliminary results

1. A total of 22.258 arrivals were picked during 2019. 986 earthquakes were associated with international catalogues, as well as 3.206 regional/local earthquakes located (Fig. 4.2.2).
2. The total magnetic field decreased by 59 nT from a yearly mean of 38.207 nT in 2018 to a yearly mean of 38.148 nT in 2019. This decrease includes global weakening of the Earth magnetic field as well as a change of the remanent crustal magnetic field, due to *Neumayer Station III* moving with the ice shelf (Fig. 4.2.3).
3. During 2019 *Neumayer Station III* moved 154.6 metres from (8:16:48.12ºW, 70:40:01.33ºS) to (8:16:51.40ºW, 70:39:56.46ºS)

4. Making use of and extending the AW network, data from the DROMSEIS seismological network has been picked and earthquakes located for the months January 2018 and February 2018. During those two months, a total of 7.025 picks has been made, and 858 earthquakes located.

Data management

- Seismological waveform data can be accessed via Geofon (https://geofon.gfz-potsdam.de/doi/network/AW). Information about arrivals and events can be retrieved from ISC (http://www.isc.ac.uk).
- Data from the geomagnetic observatory can be accessed via INTERMAGNET (https://intermagnet.github.io) and SuperMAG (http://supermag.jhuapl.edu)
- GPS data in Rinex format are available on request.

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GFZ German Research Centre for Geosciences (2016) Geomagnetic Observatories. Journal of large-scale research facilities, 2, A83. http://dx.doi.org/10.17815/jlsrf-2-136.

4.3 The Meteorological Observatory Neumayer

Holger Schmithüsen[1] (not in field), Bernd Loose[1]

[1]AWI

The Meteorological Observatory at *Neumayer Station III* is an ongoing project that is dedicated to climate monitoring. While the observatory is manned all year by a meteorologist, during austral summer major maintenance work is performed.

Objectives

The meteorological observatory at *Neumayer Station III* is dedicated to monitor essential climate variables in high quality. The station is part of various international networks, such as the Baseline Surface Radiation Network (BSRN) or the Network for the Detection of Atmospheric Composition Change (NDACC). During ANT-LAND 2019/21 the station joined the GCOS Reference Upper Air Network (GRUAN).

In order to guarantee high quality time series, the observatory is serviced once per year by permanent staff. All instrumentation and operating procedures are checked, and the yearly changing new staff is trained on site.

Fieldwork

Instrumentation and operating procedures of the following atmospheric observations were serviced in the field season 2019/20:

- 3-hourly synoptic observations
- daily upper-air soundings
- weekly ozone soundings
- continuous surface radiation and meteorological mast measurements
- satellite picture reception (HRPT)
- Automatic Weather Station (AWS) Søråsen
- Automatic Weather Station (AWS) Halfvarryggen
- single column precipitation radar

The radiosounding standard operating procedures were fundamentally updated in order to comply with GRUAN standards. In particular, the following standards were established:

- reference measurements in a “standard humidity chamber” during ground preparation
- reference measurements at launch site prior to launch
- strongly increased documentation standards
- data transfer after each launch to GRUAN lead centre

Within the DROMLAN, the meteorological observatory of the *Neumayer-Station III* offers detailed and individual weather forecast services for all activities in Dronning Maud Land, especially all aircraft operations. This service is delivered in close cooperation between the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research (AWI) and the German Weather Service (DWD). This service increases the safety of the field projects in the Dronning Maud Land and it helps to reduce weather induced idle times of expensive flight operations to a minimum. The service was provided during the entire season 2019/20.

Data management

Data of the observatory is archived in the PANGAEA data repository (World Data Center PANGAEA Data Publisher for Earth & Environmental Science (www.pangaea.de)). Furthermore, data is supplied to various international networks, mainly those organised within the World Meteorological Organisation (WMO).

4.4 CTBTO – IS27 infrasound station

Mathias Hoffmann[1], Torsten Grasse[1]

[1]BGR

Objectives

According to the Comprehensive Nuclear Test Ban Treaty (CTBT), the IS27 infrasound station is operated at the German *Neumayer Station III* Antarctic Research base as one of 60 global distributed elements of the infrasound network of the International Monitoring System (IMS). Infrasound stations measure micropressure fluctuations in the atmosphere. Therefore they are mainly focussed on the monitoring of the compliance of the CTBT with respect to atmospheric nuclear explosions. Due to the neighborhood of the VNA seismic array, seismo-acoustic studies are possible. The IS27 array is located about 3 km southwest of the Neumayer base. (Fig. 4.4.1) It consists of nine elements (Fig. 4.4.2) each equipped with a microbarometer and a data acquisition systems. (Fig. 4.4.3) They are arranged on a spiral at regularly increasing radii from the center point. The aperture of this array is about 2 km. The central array control system is installed in the Neumayer base. IS27 went operational 2003.

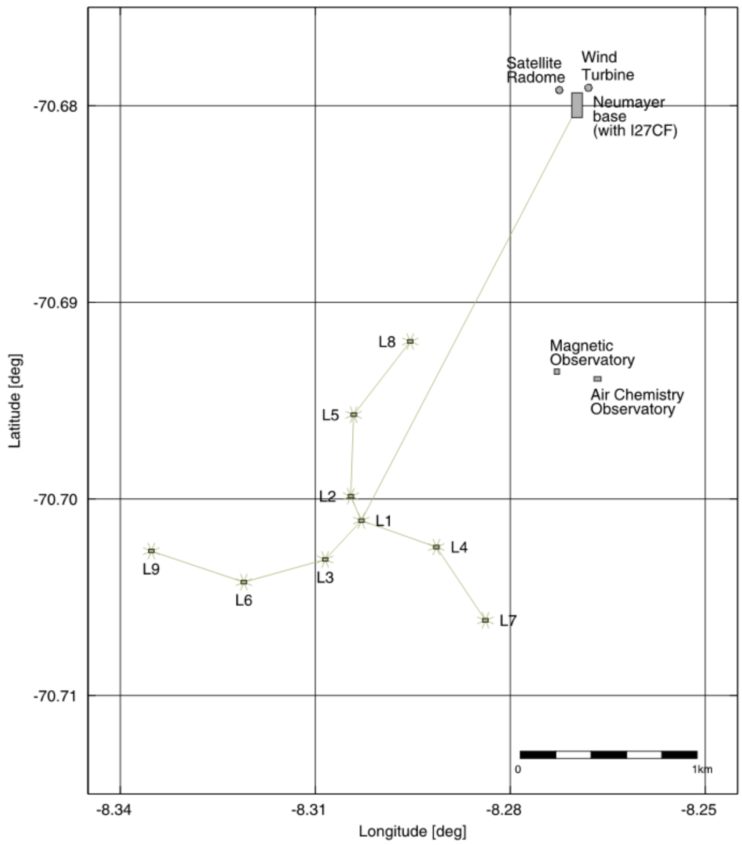

Fig 4.4.1: Map showing the location and layout of the Infrasound Array IS27 with reference to Neumayer-Station III

Fieldwork

IS27 is to be operated continuously with at least 98 % data availability over a year's time, which is required for an IMS station. Routine maintenance of the array is a prerequisite to ensure the high reliability and is normally carried out every year during the Austral summer between

December and February. During this period, the nine array elements have to be recovered from the snow and re-installed on the surface. The condition of the equipment has to be checked, hardware and software upgrades have to be installed.

Fig. 4.4.2: One of the nine infrasound elements after recovering from snow. Flagpoles mark the outer positions of the air-pressure inlet-tubes which are part of the wind-noise-reduction-system. In the center, a field-box is buried in the snow. A WiFi-Link connects each element with the Neumayer base.

Preliminary (expected) results

Data availability and quality for year 2019 met the requirement set by the CTBTO. All data were qualified for data processing at CTBTO.

Waveform-data from IS27 contributed to several recently conducted atmospheric research studies; please refer to references list.

Data management

Archived data as well as real-time infrasound data and metadata can be obtained from BGR via FDSN-Webservice (https://eida.bgr.de).

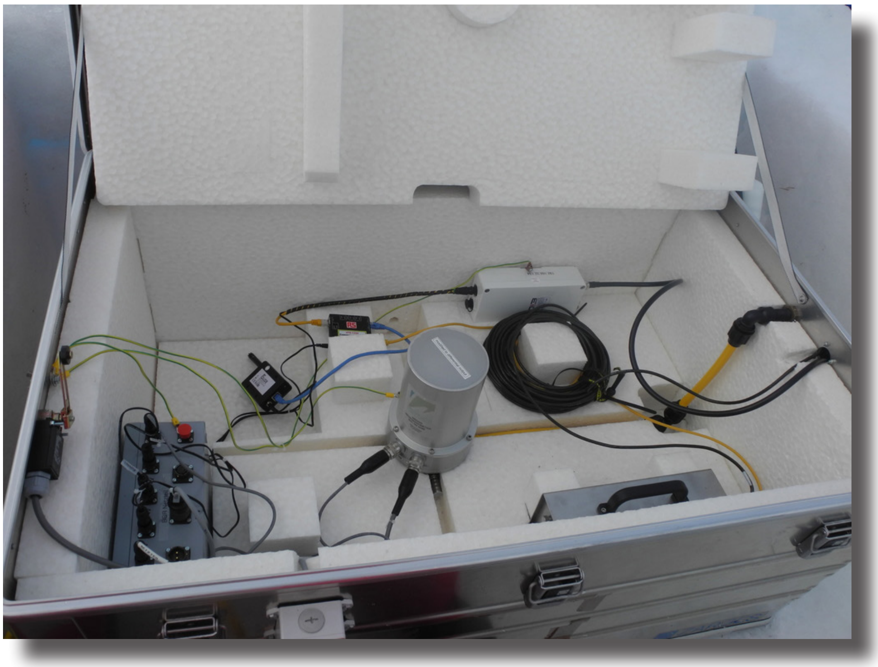

Fig. 4.4.3: The insulated field-box contains the microbarometer (in the middle), data acquisition system as well as the power supply and a communication unit

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4.5 AFIN – Antarctic Fast Ice Network

M. Koch (AWI), Stefanie Arndt (AWI, not in field) [1]AWI

Objectives

Sea ice fastened to coasts, icebergs and ice shelves (fast ice) is of crucial importance for climate and ecosystems. At the same time, it is not represented in climate models and many processes affecting its energy- and mass balance are currently only poorly understood. Near Antarctic ice shelves, this fast ice exhibits two unique characteristics that distinguish it from most other sea ice:

1. Ice platelets form and grow in super cooled water masses, which originate from cavities below the ice shelves. These crystals rise to the surface, where they accumulate beneath the solid sea ice cover. Through freezing of interstitial water, they are incorporated into the sea ice fabric as platelet ice.

2. A thick and highly stratified snow cover accumulates on the fast ice, altering the response of the surface to remote sensing and affecting sea ice energy- and mass balance.

At the same time, fast ice is ideal to monitor sea ice and its seasonal evolution, because it may be accessed from nearby stations. In order to improve our understanding of sea ice processes and mass balance, we perform a continuous measurement program on the fast ice of Atka Bay, Antarctica. This work contributes to the international Antarctic Fast Ice Network (AFIN), which was initiated as legacy project under the International Polar Year (IPY) and is set out to establish an international network of fast-ice monitoring stations around the Antarctic coastline. The monitoring program at *Neumayer Station III* started in 2010.

Fieldwork

(1) Manual measurements of sea ice and snow thickness

Manual measurements of sea ice and platelet ice thickness, freeboard, and snow depth (drillings and stake measurements) were repeated along a 25-km-long transect across Atka Bay once per month (Fig. 4.5.1). As in the previous years, 6 fixed sampling sites have been revisited monthly between annual formation and break up to obtain the mentioned measurements.

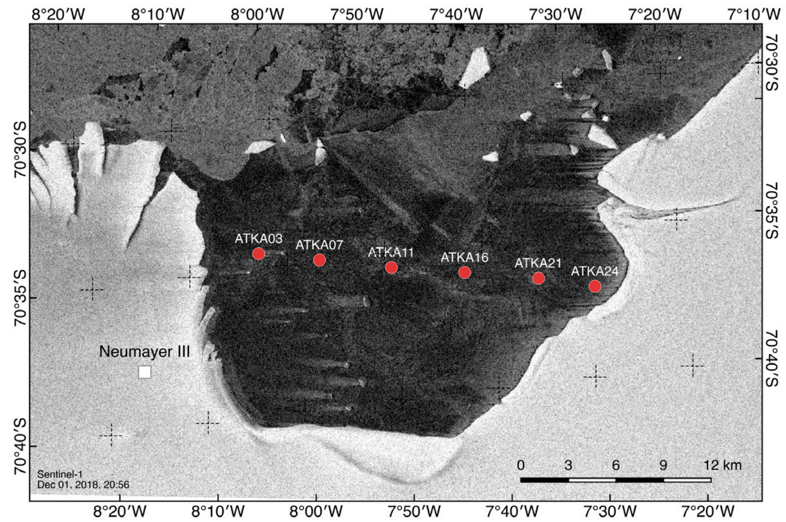

Fig. 4.5.1: Overview on the measurement sites in Atka Bay for the season 2019. ATKA03-24 denote the routinely measurement sites of AFIN. Numbers (03-24) state the distance to the western (E-W transects). The background of the map shows a Sentinel-1 SAR image recorded on 04 December 2018.

During the season 2019/2020, the sea-ice conditions in Atka Bay have been rather unusual as the fast ice broke up during the summer season before but only the ice in the eastern part left the bay. The remaining sea ice consolidated in the bay causing a rather rough sea-ice surface.

First sea ice, platelet ice and snow thickness measurements were carried out on 09 May 2019. Since entering the sea ice was not yet safe in the entire bay, only a first section (until ATKA07) of the route could be worked on. Afterwards, in total, 4 series of the entire transect could be conducted. Additional 2 sampling transects have been carried out between ATKA11 and ATKA24. Last measurements were performed on 29 December 2019. The fast ice was closed on 08 January 2020. Table 4.5.1 summarizes all mentioned manual measurements.

Tab. 4.5.1: Overview of all manual sea ice and snow thickness measurements along the standard transect. The ATKA sites correspond with the measurement sites in Fig. 4.5.1.

Datum	ATKA03	ATKA07	ATKA11	ATKA16	ATKA21	ATKA24
09 May 2019	X	X				
09 Jun 2019	X	X				
19 Jul 2019	X	X	X	X	X	X
22 Aug 2019	X	X	X	X	X	X
11 Oct 2019			X	X	X	X
15 Nov 2019	X	X	X	X	X	X
14 Dec 2019	X	X	X	X	X	X
29 Dec 2019			X	X	X	X

(2) Electromagnetic sea ice thickness measurements

In addition to the manual sea ice and snow thickness measurements, a ground-based electromagnetic induction device GEM (Geonics Limited, Mississauga, Ontario, Canada) was operated measuring total sea ice thickness (sea ice thickness plus snow depth). Due to technical challenges and the described difficult sea-ice conditions, such a transect was only conducted once on 15 November 2019 along the standard transect crossing Atka Bay.

(3) Snow depth measurements with the MagnaProbe

In addition to the manual snow depth measurements at the drilling holes, snow depth was derived with a GPS-equipped Magna Probe (Snow Hydro, Fairbanks, AK, USA). It was operated simultaneously to the GEM transects in order to calculate the actual sea ice thickness as the difference of total sea ice thickness and snow depth. It was therefore operated once on 15 November 2019. In addition, snow depth measurements were taken during the last transect on 29 December as part of the handover procedure to the following overwintering team.

(4) Deployment of autonomous ice tethered platforms (buoys)

In order to measure sea ice and snow thickness throughout the seasonal cycle on an hourly basis, two autonomous ice tethered platforms (buoys) have been deployed on the fast ice in Atka Bay approx. 50 meters north of ATKA11 (see Fig. 4.5.1): One Ice Mass Balance buoy (IMB) deriving the sea ice growth as well as one Snow Depth Buoy measuring the snow accumulation over the course of the year, both 29 August 2019. Both buoys drifted with the ice into the Weddell Sea after the break up in January 2020. While the Snow Buoy died already on 28 February 2020 while drifting south close to the Antarctic shelf edge, the IMB died in the northeastern Weddell Sea on 29 April 2020.

Snow thickness measurements with the Snow Buoy next to the air chemistry observatory near *Neumayer Station III* were continued (since January 2013) at the same location. During this period, the Snow Buoy was once lifted (29 November 2018) to avoid a complete coverage in the snow.

(5) Vertical water profiling below the fast ice

A Conductivity-Temperature-Depth (CTD) sensor suit was lowered through a drilled hole twice at ATKA11, on 29 August and 14 October 2019.

Preliminary (expected) results

Fig. 4.5.2 summarizes all snow, sea ice and platelet ice thickness measurements as well as the observed freeboard over the season.

Results from the GEM measurements are not shown here, as the configuration of the instrument needs to be adapted in order to get accurate sea-ice thickness values. This will be done for the upcoming season.

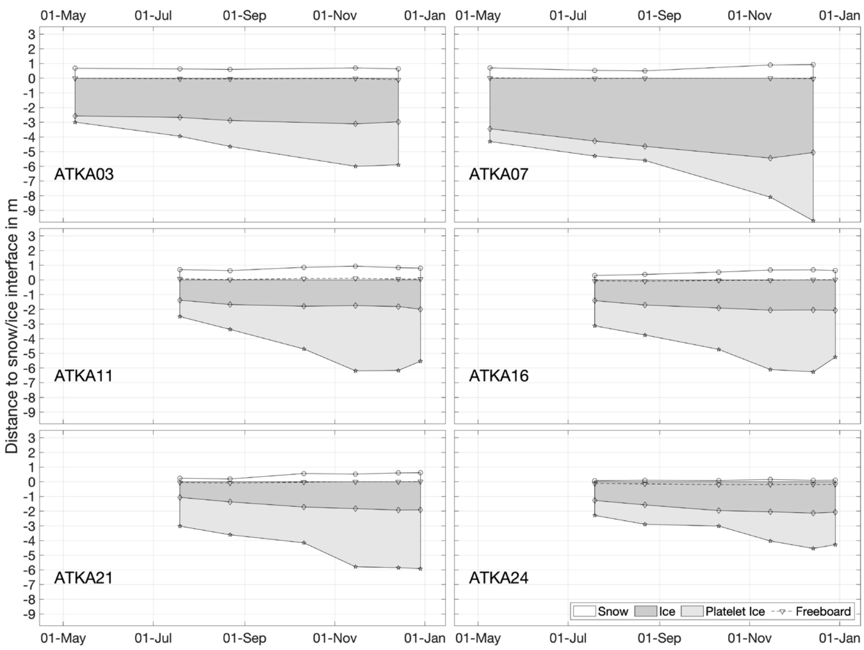

Fig. 4.5.2: Overview of all manual snow depth, sea ice and platelet ice thickness as well as freeboard measurements for the 6 ATKA points along the standard W-E transect (Fig. 4.5.1) in 2019

Fig. 4.5.3 shows the snow accumulation of the deployed Snow Depth Buoy 2018S88 (at ATKA11) for the time period from 29 August 2019 to 28 February 2020. The initial snow depth at the deployment site was already 80 cm. Even though, 4 discernible snow accumulation events can be identified within the following 6 months, a snow depth increase of approx. 15 cm only could be observed. From beginning of January onwards, the snow depth decreased/ melted to a level of 80 cm, and therefore reaching the initial snow depth again.

Sea ice growth data from the IMB will be only processed at a later stage.

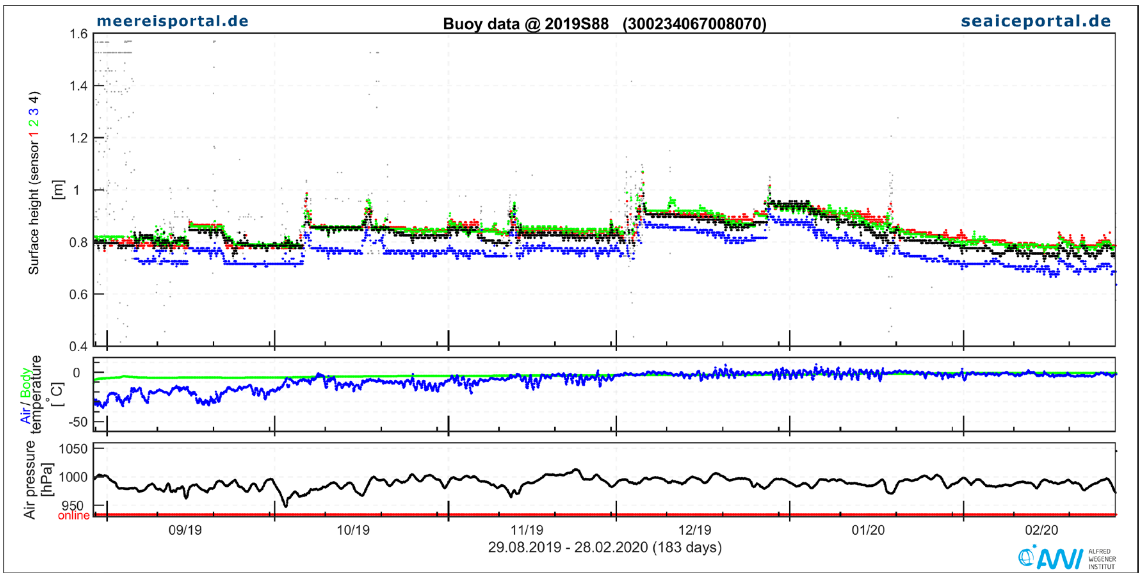

Fig. 4.5.3: Time series of snow accumulation along with respective meteorological conditions for Snow Buoy 2018S88, deployed on 29 August 2019 at ATKA11 (Fig. 4.5.1)

Data management

All manual drilling measurements are already post-processed and will be published in the PANGAEA data repository (World Data Center PANGAEA Data Publisher for Earth & Environmental Science (www.pangaea.de)) within three months.

The sea-ice thickness data from electromagnetic measurements as well as snow depth data from MagnaProbe measurements will be released following final processing after the field season ANT-LAND 2019/2020 or depending on the completion of competing obligations (e.g. PhD projects), upon publication as soon as the data are available and quality-assessed. Data submission will be to the PANGAEA database.

All buoy positions and raw data are available in near real time through the sea ice portal www.meereisportal.de. At the end of their lifetime (end of transmission of data), all data will be finally processed and made available in PANGAEA. The Snow Buoys report their position and atmospheric pressure directly into the Global Telecommunication System (GTS). Furthermore, all data are exchanged with international partners through the International Program for Antarctic Buoys (IPAB).

4.6 SPOT – Single Penguin Observation and Tracking

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SPOT is a long-term remote-controlled observatory to monitor emperor penguins continuously throughout the year for biophysical, ecological and behavioral studies.

Objectives

Continuous data collection over prolonged time periods is the cornerstone of behavioral and ecological studies. Such data can be used to analyze a large scale of behavioral and ecological problems, from an individual animal to population trends. Time lapse imaging has gained significant interest within the last decade and is now a standard tool due to the large availability of low-cost digital cameras (Kucera & Barrett, 1993; Newbery & Southwell, 2009; Lynch, Alderman & Hobday, 2015) as well as the steadily increasing capability of image processing software (Dell et al., 2014; Gerum et al., 2016). However, in remote and climatically harsh locations such as Antarctica, data acquisition and physical access to the observation system can be challenging. We implemented a remote-controlled and energetically self-sufficient observatory (SPOT, Fig. 4.6.1) specifically designed to operate in Antarctic conditions.

Fig. 4.6.1: Detailed picture of the SPOT Observatory recorded in November 2019

The observatory is designed with the aim to investigate the population and behavioral ecology of emperor penguins (Zitterbart et al., 2011, 2014; Gerum et al., 2013). The challenges in observing emperor penguin colonies are that those are poorly accessible, and their mating and breeding behavior can only be observed during the coldest and darkest months, with wind speeds up to 150 km/h and temperatures as low as -50°C. Therefore, the observatory needs to be, autonomous and remotely controllable, as well as require little maintenance. As emperor penguins do not build nests, and incubate their single egg on their feet, the whole colony can move within an area of several km^2. To observe such a large area, we installed 7 stationary wide-angle cameras for panoramic overview images, and a steerable 29 megapixel camera mounted on a pan-and-tilt unit as well as a long wave thermal imaging camera. Both, the thermal and the color camera, are equipped with a telephoto lens for either high-resolution images, stitched panoramic images, or video recordings of the colony.

SPOT was deployed in the Austral summer season 2012/2013 at Atka Bay (70°37.0'S, 8°9.4'W), approximately 8 km north of *Neumayer Station III*, on the Ekström Ice Shelf (Richter et al., 2018). Since 2013, we have been collecting wide-angle overview images at a rate of 1 frame per minute to determine the colony position, and when visibility conditions permit daily panoramic images stitched from high-resolution images to count penguins, and on-demand high-resolution video recordings of the colony at 5 frames per second (fps).

Fieldwork

During the ANT-Land 2019/20 field campaign, SPOT underwent its annual maintenance cycle. In past seasons, especially during times of high humidity in March – June, the thermal imaging camera often developed a several mm thick ice buildup on the lens. Due to the germanium window, the thermal imaging camera case is not equipped with a window heater. To stop ice buildup, we installed a remote-controlled flap that closes tightly with the thermal imaging camera's enclosure (Fig. 4.6.2). We exchanged the barix+io12 micro processing units in the SPOT observatory, as well as replaced the current battery back with 7 used 110Ah AGM gel batteries (approx. 6 % capacity, 400 Ah). Furthermore, the SPOT location was plowed and leveled and SPOT repositioned with support from AWI logistics.

Fig. 4.6.2: Left: Camera array with new self-closing flap on thermal imaging camera. Right: Remote-controlled, heavy-duty motor on top of thermal imaging camera to drive the closing flap.

During the ANT-Land 2019/20 field season, the data acquisition and storage was entirely migrated from a dedicated workstation located in the computing center at *Neumayer Station III* to a virtual server operated by AWI. This reduces the hardware footprint in the computing center whilst increasing redundancy as snapshots of the operating system are generated daily. We implemented an automated process to generate stitched panoramic high-resolution images at *Neumayer Station III*, that now allows to transmit the panoramic images through the satellite link. Therefore, counts of emperor penguins are now produced in near-real time. Most data processing scripts that were still written in PERL programming language from the time SPOT was initially designed were translated to python for simplification. The entire migration from PERL to python will be finished in 2020.

Data collection throughout the winter 2019 went without major problems. Overview cameras recording the position and density of the colony were operational throughout the year and collected a total of 252,345 minutes of data throughout the year. We experienced a few problems with the wifi antenna at *Neumayer Station III* in late March and early April before the penguins arrived at the colony, which led to 9 days without data, and a power outage of SPOT observatory in mid-July, which led to 7 days of data loss. Data after December 12 was not transferred to Germany yet and is therefore missing in the data overview plot (Fig. 4.6.3, top). The high-resolution RGB camera was operational throughout the year and recorded images on demand when daylight, penguin's position were favorable and the power reserves of SPOT observatory enough. We recorded during 169 days a total of ~18,600 minutes (~4.5 million pictures) distributed over the whole year (Fig. 4.6.3, middle). The thermal imaging camera was operated when possible in conjunction with the RGB camera. A total of ~19,800 minutes (~10 million pictures) of thermal imaging data was recorded during 53 days (Fig. 4.6.3, bottom). To count emperor penguins and to study their reorganization processes on a colony scale level, we acquired a total of 1428 gigapixel size panoramic images throughout 2019. An example is provided in Fig. 4.6.4.

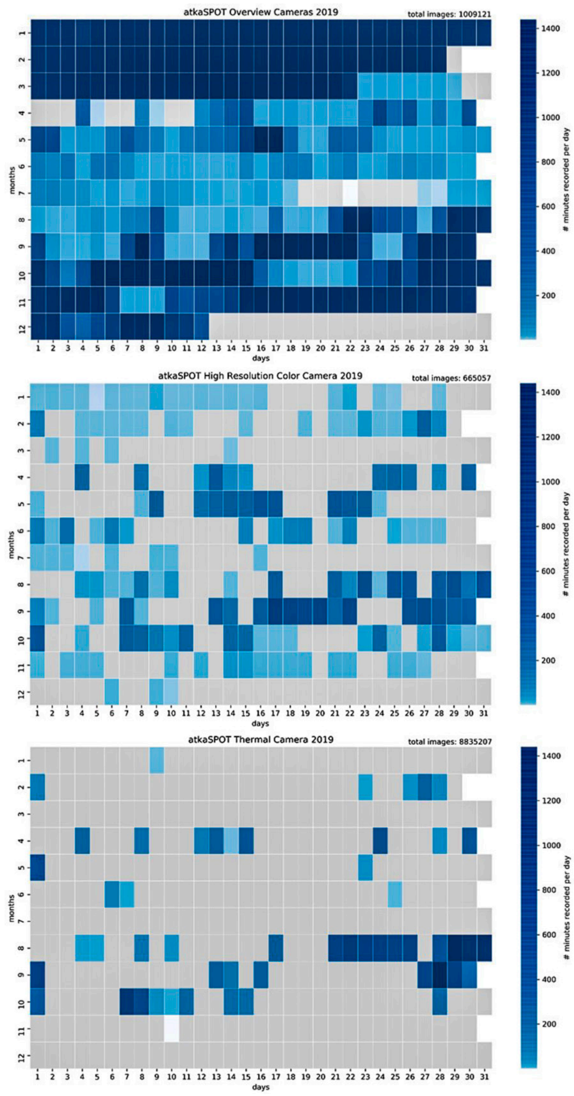

Fig. 4.6.3: Data collection overview. Minutes per Day data collected of the respective camera system: Overview cameras (top), high-resolution color camera (middle), and thermal imaging camera (bottom).

Preliminary (expected) results

We have been operating SPOT now for 7 breeding seasons with increasing success, which is reflected in annual operation time and data collected. Whilst during the first 2 years we had hardware failure of different components, this has not occurred since the winter of 2015. The operation is conducted completely remotely with support from the Overwinters in case it is needed. Most assistance is needed to grease the wind generators every 3 months, as well as to de-ice the overview cameras, which do not have a dedicated heating, especially in autumn when rare freezing fog is possible. Counts throughout the seasons 2018 and 2019 clearly show the arrival pattern as well as the occupation peak of the colony when presumably the whole population is present in May.

Data management

All data recorded by SPOT is transferred annually to the AWI Data repository into the PANGAEA data repository (World Data Center PANGAEA Data Publisher for Earth & Environmental Science (www.pangaea.de)).and stored in the long-term archive.

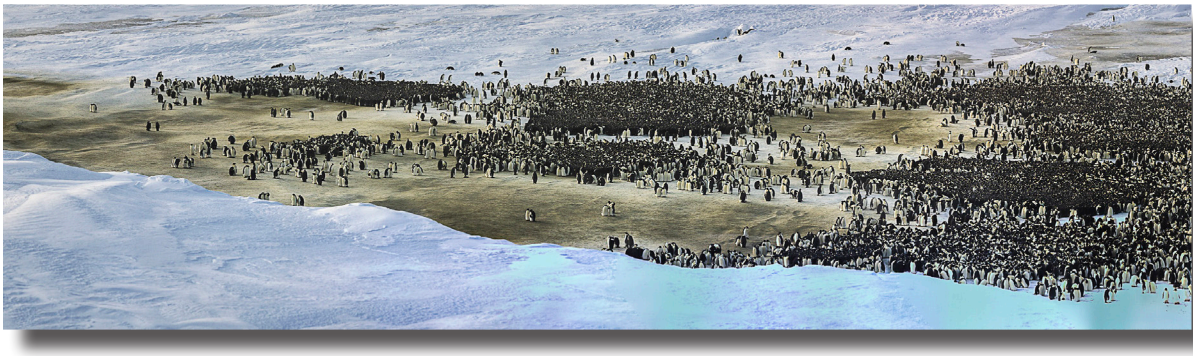

Fig. 4.6.4: High-resolution panoramic images of the whole Atka Bay colony created on July 9th 2018

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4.7 PALAOA – Ocean Acoustics

Stefanie Spiesecke[1] (not in field), Olaf Boebel[1] (not in field), Elke Burkhardt[1] (not in field), Karolin Thomisch[1] (not in field), Ilse van Opzeeland[1] (not in field)

[1]AWI

Objectives

The restricted accessibility of the Southern Ocean throughout most of the year confines our knowledge of the distribution patterns, habitat use and behaviour of marine mammals in this area. Most of the Antarctic marine mammals produce species-specific vocalizations during a variety of behavioural contexts. Hence, passive acoustic monitoring (PAM) offers a valuable tool for research on these species, capable of covering large temporal and spatial scales. Particularly, in remote areas such as the Southern Ocean, moored PAM recorders are the tool of choice, as data can be collected year-round, under poor weather conditions, during darkness and in areas with dense ice cover.

The PALAOA (Perennial Acoustic Observatory in the Antarctic Ocean) located on the Ekström Ice Shelf since 2005, collects continuous underwater recordings from a coastal Antarctic environment using a hydrophone deployed at ca. 160 m depths. The recorded data allows an unprecedented investigation of the temporal patterns in marine mammal biodiversity at Atka Bay.

Fieldwork

During a previous supply of the *Neumayer Station III station* from 28 Dec 2014 until 31 Dec 2014 by *Polarstern*, an aluminum box, containing modified Sonovault electronics, was installed at the position of the former PALAOA container. It was recessed into the snow and is covered with a wooden board and some snow. The box (80 cm x 60 cm x 60 cm) includes a Reson input module EC6073 for the active hydrophone (Reson TC4032) and a SonoVault electronics module, similar to those used in the moored recorders. For the power supply, four 90 Ah, 12V batteries were included, two connected in row for each, the active hydrophone and the recording electronics. The battery setup was changed later in 2015 to batteries two in a row and those rows in parallel, supplying both, the hydrophone and the recording electronics. Storage capacity is 4.4 TB (35 x 128 GB SDXC). With a sampling rate of 80 kHz at 24bit and a file size of 600s the PALAOA system was expected to run up to 6 months. Servicing is provided by the overwintering team of *Neumayer Station III*. Based on the experience from the Neumayer staff, a servicing interval of approx. 3 months proved to be necessary and was attended to by Neumayer staff since 2018/2019 Antarctic Season. The responsible person at *Neumayer Station III* is the radio officer.

The last on-site visit by the PALAOA project technical staff was during Antarctic Season 2018/2019.

During the storage and battery exchange in early 2020 by the Neumayer radio officer, it was discovered that while performing a synchronization with the attached GPS receiver GPS.sync, the system time was incorrectly set on the electronics. As a result, the date logged within the recorded file headers and file names was incorrect. Investigation into this problem found it to be a problem in the handling of the GPS satellites' 10-bit week counter by the GPS chip. This counter reaches its limit after 1024 weeks and rolls back to zero (GPS Week Number Rollover – WRNO). The GPS chip within the used GPS receiver does not have the compliant firmware to handle this rollover. The issue can only be fixed by replacing the chip. Knowing this, however, the incorrect date can be corrected during pre-processing of the data by adding the week difference to the date. Time settings are not affected by the error. In 2020/2021, a fixed GPS receiver will be sent to *Neumayer Station III*. Until then, GPS synchronization will be continued with the erroneous date setting.

On March 10, 2020, the remaining hydrophone cable route of the original PALAOA setup was removed from the shelf. A total of 55 poles were excavated during the removal of the cable. The cable was disconnected at a connector close to the entry point into the ice. The part of the cable, which is vertically frozen into the ice and connects to the submerged hydrophone remains in the ice. Its' current position (70.50427° S, 008.20300° W) was marked.

The current position of the PALAOA station recording unit is:

70° 30.321' S 008° 12.579' W

The station continues to be in operation, with the hydrophone being located approx. 400 m from the ice shelf edge.

Data management

Tapes with data from 2019/2020 arrived in Bremerhaven in April 2020 and were copied into the OZA project folder on the Isilon Server. A further backup was made on the OZASRV1. Pre-processing of data and analysis are still pending. A routine to fix the WRNO date problem is in development.

4.8 Neuromayer – Neurophysiological changes in human subjects during long-duration over-wintering stays at *Neumayer Station III* in Antarctica

Alexander Stahn[1,2], Mathias Basner[1] (not in field), David Dinges[2] (not in field), Hanns-Christian Gunga[2] (not in field), Ruben Gur[1] (not in field), Simone Kühn[3] (not in field), Brad Nindl[4] (not in field), David Roalf[1] (not in field), Pete Roma[5] (not in field)

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[3]MPI, [4]Pitt
[5]NASA JSC

Objectives

The overarching objective of the project is to investigate the effect of long-duration Antarctic stay on crew health and behaviour. The research will be performed as part of the NASA sponsored project "NSCOR for Evaluating Risk Factors and Biomarkers for Adaptation and Resilience to Spaceflight: Emotional Valence and Social Processes in ICC/ICE Environments". The goals of the project are to further define the likelihood and consequences of NASA's primary "Risk of Adverse Cognitive or Behavioral Conditions and Psychiatric Disorders" and "Risk of Performance and Behavioral Health Decrements Due to Inadequate Cooperation, Coordination, Communication, and Psychosocial Adaptation within a Team", and the secondary "Risk of Incompatible Vehicle/Habitat Design" by evaluating the effects of variation in induced environment (e.g. habitable volume, variations in background acoustics, ambient lighting and ambient temperature). We will evaluate healthy adults working and living at *Neumayer Station III,* with the goal of identifying biological and behavioral factors associated with resilience and overall adaptability to the demanding conditions analogous to those found in prolonged spaceflight (e.g., physical isolation, confinement, monotony, social isolation, etc.). The primary focus will be on inter- individual differences relative to resiliency, emotional regulation (positive/ negative valence), biological basis of social support, meaningfulness of work, and individual perceptions of well-being. The project leverages the NIMH Research Domain Criteria (RDoC) heuristic framework to conduct experimental studies to identify biological domains (molecular, circuitry, physiology) and behavioral domains that relate to individual adaptation and resiliency (as well as behavioral vulnerability) (Maestripieri et al., 2016). RDoC's emphasis on examining each construct provides an integrative approach that is appropriate for identifying individual differences in vulnerability to multiple stressors in extreme environments. In addition, RDoC's 6 differences and variations in the nature and degree of damage to those circuits, as well as the variations and contributions of a complex interplay of developmental, compensatory, and environmental factors (Morris et al., 2012). We will identify predictive indicators and biomarkers for resilience and adaptation in individuals and teams, to aid in selection and individualized countermeasure development with the goal to maintain and optimize performance capability and behavioral health during long-duration missions. The specific aims (SA) are as follows:

<u>SA1</u>: Identify and quantify individual differences in adaptation and resilience, and key threats to and promoters of mission relevant behavioral health and performance. We will use components of the RDoC framework to look across individual risk factors in order to identify and validate molecular, circuitry and physiological measures that can be used for monitoring and selection of individuals who are highly resilient to the key behavioral health and performance threats in isolation and confinement.

<u>SA2</u>: Elucidate the biological basis of social support in isolation and confinement to assess individual sociability and the neurobehavioral contributions to resiliency and/or adaptability of engaging positively in social interactions, tolerance, and awareness (e.g., affiliation, attachment).

SA3: Identify how meaningful work mediates the relationship between risk factors, the valence and social process domains, and operational outcomes, as well as direct effects of meaningful work on performance. The intent is to identify a sensitive, reliable, valid, and operationally feasible set of measures for measuring and monitoring meaningfulness of work.

SA4: Identify how positive and negative valence systems impact on psychological well-being and performance when confronted with the adverse conditions found in prolonged isolation and confinment. We will identify biomarkers and psychological report measures associated with the effects of well-being on performance and determine their contribution to the positive/negative valence systems involved in individual adaptation and resilience to isolation and confinement.

The project will be based on a close cooperation between the Polar Institute for Polar and Marine Research and several renowned international partners, including Charite, Ludwig Maximilian University of Munich, the University of Pennsylvania, Harvard, and NASA.

Fieldwork

Data will be collected in crew members at *Neumayer Station III* as part of ANT-LAND 2018/19, 2019/20 and 2020/21. Our primary outcome will be structural and functional brain changes assessed by MRI before and after the winter-over. In addition, we will also assess behavior and cognitive performance with sensitive but unobtrusive state-of-the-art cognitive and psychosocial measurement tools. These measures will be performed before, after and during the winter-over. We also propose to draw and subsequently freeze about 25 ml of blood from all experimental subjects before, during and after the campaign, which will later allow for the identification and time course of biological markers of vulnerability to the effects of prolonged exposure to Antarctic overwintering. To parse out the effects of reduced sensory stimulation from other stressors during long duration space missions such as social isolation, crew conflicts, sleep and circadian disorders, and reduced physical activity levels (Palinkas & Suedfeld, 2008), we will assess additional physiological measures and endpoints, which have already been successfully implemented in previous experiments in Antarctica. The sample rate will vary from continuously to once monthly, and is optimized relative to crew burden/compliance and scientific return. Pre- and in-expedition data collection for the 39th overwintering was successfully completed. The post-expedition data collection was scheduled in March 2020, and had to be cancelled until further notice because of the Covid-19 pandemic. Pre-mission data collection for the 40th overwintering campaign was accomplished in November 2019. In-mission data collection for this crew is currently ongoing at *Neumayer Station III*.

Preliminary (expected) results

It is expected that the multiple stressors associated with long-duration overwintering lead to neurobehavioral changes as assessed by structural and functional brain imaging, key neurotrophins and behavior (e.g. mood and cognitive performance). We also expect that resilience will reflect inter-individual differences in sensitivity to the stressors associated with prolonged Antarctic missions.

We recently published data on the neurobehavioral effects of overwintering on *Neumayer Station III* in the *New England Journal of Medicine* (Impact Factor: 70.67) (Stahn et al., 2019). We obtained high resolution T1- and T2-weighted magnetic resonance imaging (MRI) data using a Siemens Tim Trio 3T scanner in these expeditioners before and 1.5 months after the mission to study changes in the volume of subsections of the hippocampus and of whole-brain gray matter volume. We analyzed cognitive performance and brain-derived neurotrophic factor (BDNF) via venous blood samples in all nine crew members before, during, and after the expedition. To account for biological variation and aging effects on brain changes we obtained longitudinal data from nine controls matched for age, sex, and initial hippocampal volume. There were reductions in hippocampal volume of the dentate gyri from before to after the expedition when compared the changes over 14 months in controls in the eight expeditioners with MRIs (mean group decrease in volume ±SE: 32±13 mm^3, equivalent to 7.2±3% volume reduction) (Figure 4.8.1 A). Whole-brain imaging showed decreases of gray matter probability in the left parahippocampus (mean group decrease ±SE: 3.84±0.72%), and in the right lateral (mean group decrease ±SE: 3.33±0.48%) and left medial prefrontal cortex (mean group decrease ±SE: 2.99±0.25%) (Fig. 4.8.1 B). After the first quarter of the expedition serum BDNF concentration was reduced compared to prior to the expedition and did not recover at 1.5 months after the end of the expedition (mean reduction ±SE: 11±1.5 ng/mL, 45±4.9 %) (Fig. 4.8.1 C). Reductions in BDNF from pre- to post-mission were associated with decreases in dentate gyrus volume (R^2=0.47). The reductions in dentate gyrus volume were also associated with lower cognitive performance in tests of spatial processing (R^2=0.87) and the resolution of response conflicts test (R^2=0.82) but there was no reduction in performance in other cognitive tests (i.e., Digit Symbol Substitution, Stroop Congruent task).

These data confirm the impact of environmental and social variation on hippocampal plasticity (van Praag et al., 2000). The prolonged social and environmental monotony in the expeditioners we describe may have been mediated by reductions in BDNF and volumetric brain changes. The vulnerability of the dentate gyrus to environmental deprivation in comparison to other hippocampal subfields is similar to findings from animal models, suggesting a possible link between hippocampal neurogenesis, stress-induced behavioral changes, and environmental deprivation (Gould et al., 1997; Stranahan et al., 2006; Schloesser et al., 2010). A critical question that derives from these findings relates to inter-individual responses to the prolonged isolation and confinement. Our data suggest specific phenotypes that show considerable variation in their response to the social and environmental monotony. In addition, the recovery of these changes is currently unknown. Understanding these phenotypes and the time course of adaptations and the recovery could provide critical information about markers of neurobehavioral resilience aid in the development of individualized countermeasures based on vulnerability. These data could provide expedition planners and system developers with strategies for crew selection and predicting, monitoring and mitigating crew health and performance risks during future exploratory missions associated with prolonged isolation and confinement.

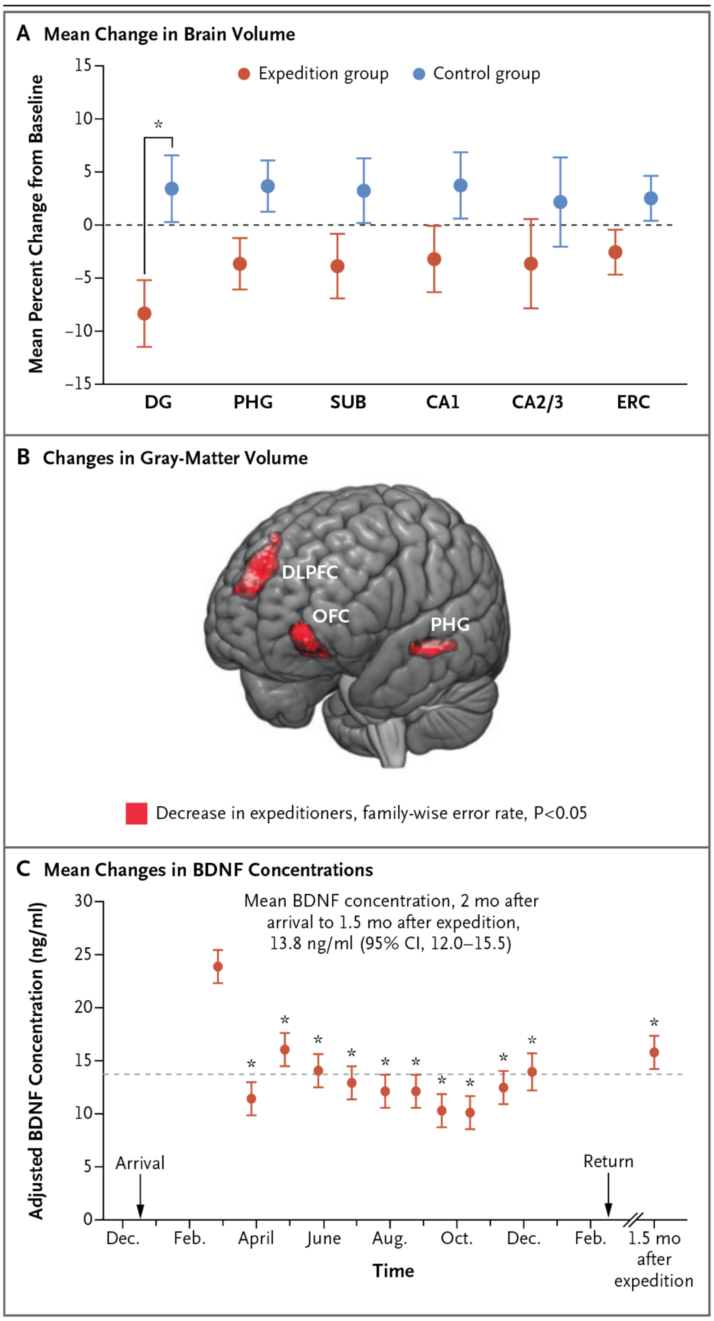

Fig. 4.8.1: Changes in Brain Volume and Brain-Derived Neurotrophic Factor (BDNF) Concentrations in Antarctic Expeditioners. Panel A shows changes in hippocampal subfields in expeditioners and age- and sex- matched controls. Mean changes in brain volume were adjusted for changes in cardiopulmonary fitness (maximum oxygen uptake). The asterisk indicates P<0.01 for the comparison of changes in dentate gyrus volume between persons in the expedition group and those in the control group. Bars indicate standard errors. CA1 denotes cornu ammonis subfield 1, CA2/3 cornu ammonis subfields 2 and 3, DG dentate gyrus, ERC entorhinal cortex, PHG parahippocampal gyrus, and SUB subiculum. Panel B shows the results of a whole-brain analysis based on T1-weighted magnetic resonance imaging data with the use of voxel-based morphometry. Red regions indicate lower gray-matter volume in the right dorsolateral prefrontal cortex (DLPFC), the left orbitofrontal cortex (OFC), and the left PHG in the expeditioners than in the controls. Data were corrected for multiple comparisons with family-wise error correction (P<0.05) and were adjusted for age, sex, and maximum oxygen uptake. Panel C shows the mean BDNF concentrations during and after the 14-month Antarctic expedition as measured from blood samples. Data were adjusted for baseline

measurements before the trip to Antarctica. Bars indicate standard errors. BDNF concentrations were significantly lower in the expeditioners while they were in Antarctica (at all time points) than the concentrations at the first data collection after arrival in Antarctica (P<0.001, Bonferroni-corrected for multiple comparisons). © Stahn, A. C., Gunga, H. C., Kohlberg, E., Gallinat, J. Dinges, D. & Kühn, S. Brain changes in response to long Antarctic expeditions. New England Journal of Medicine 381(23): 2273-2275 (2019), https://www.nejm.org/doi/full/10.1056/NEJMc1904905.

Data management

Data will be analyzed at the PI's laboratory at Charité, MPI, Penn and Pitt. Data will be pseudonymized and stored on a central server that is backed up and managed by the universities' IT programs. Results will be publicly disclosed in a timely manner after completion of the data collection by submission to peer-reviewed journals with authorships that accurately reflects the contributions of those involved. One year after final data collection the data will be submitted to NASA, which will be archived in the NASA Life Sciences Data Archive (LSDA) (http://lsda.jsc.nasa.gov/) for the benefit of the greater research and operational spaceflight community. We will meet all requirements set forth by NASA to share our data with the research community in general and NASA's Life Sciences Data Archive (LSDA). De-identified data will be submitted to the LSDA that can then be made available for internal and external-to-NASA peer- reviewed research studies following a thorough review and approval process by LSDA and after appropriate JSC IRB approval. The de-identified that we will submit to LSDA will include individual data points but any identifying information will be removed. We will carefully attend to any characteristic that might make the data fields identifiable (e.g., Campaign, Analog, mission length and/or gender).

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4.9 KottasPEGEL – Kohnentraverse 2019/2020

Olaf Eisen[1] (not in the field)
Lutz Eberlein[2], Eric Buchta[2]

[1]AWI
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Outline

Specific surface mass balance is one of the most important parameters to determine the current overall mass balance of the Antarctic ice sheet. At the same time, it is also one of the inaccurately known quantities. Although remote sensing methods have been developed to track surface accumulation over time and interpolate in space, reliable estimates still crucially depend on on-site measurements of surface accumulation. To track the development of surface mass balance in a changing climate, it is not only important to cover white spots, but also obtain continuous records of snow accumulation at selected sites. Only long-term time series, which cover larger distances, allow to reliably characterise the statistical properties of snow surface accumulation, i.e. the changes from year to year and changes in space. Only few of such records exist to date, mostly along regularly visited traverse routes between permanent stations and summer field camps or stations. Measurements of snow accumulation and density can be relatively easily determined in the field. In our case the former project "Kottasdichte" is now merged with the project "Kottaspegel".

Objectives

The objective of Kottaspegel is to determine the current spatial distribution of snow/firn density and surface mass balance (accumulation) along traverse from *Neumayer Station III* to *Kohnen Station*. Results will be put in context to former measurements of density in the same region.

Fieldwork

Between 21 to 24 January 2020 as part of the traverse of the project "Investigating glacial-isostatic adjustment on basis of geodetic GNSS observation campaigns in *Dronning Maud Land, East Antarctica"* stake readings were performed from *Neumayer Station III* to Kottas Camp. Measurements were performed with the standard setup, but for the first time operating from a Toyota Hilux instead of a snow machine. Because of time constraints no density measurements were performed. In total, 601 stakes readings were obtained at 388 locations (i.e. partly several stakes per location).

Preliminary (expected) results

Collation of measurement values is ongoing. For the scientific interpretation of results, we plan to jointly analyse all snow height and density measurements in the regions of interest obtained over the last decades.

Data management

It is planned to collate the density data collected over several decades in a joint data base, and the remaining data will be uploaded to PANGAEA data repository (World Data Center PANGAEA Data Publisher for Earth & Environmental Science www.pangaea.de after primary publication in a scientific journal.

4.10 WSPR beacon – Radio beacon at *Neumayer Station III* for evaluation of southern hemisphere radio propagation

Michael Hartje[1](not in field), Ulrich Walter[2] (not in field) [1]HS Bremen, [2]TU München

Objectives

The objective of this project is to gain knowledge about the propagation of radio waves in the ionosphere at Antarctic latitudes and at frequencies between 100 kHz and 50 MHz. This is achieved by using transmitting and receiving beacon signals from about 1,500 ham radio stations spread over the globe. These stations transmit as beacons or/and report the received beacon reports so-called “spots” from other stations to a common wsprnet database system. The beacon messages use the WSPR protocol. WSPR is the abbreviation for *weak signal propagation reporter*, which has been developed and introduced in 2008 by Joe Taylor, ham radio call sign K1JT, physicist and Nobel Laureate.

The project was scheduled to last for at least one year with request to extend it over a full sun spot cycle of 11 years until 2030.

The project is sponsored by the two prime investigating institutions as well as by DARC (German Amateur Radio Club) and supported by several highly dedicated private persons.

After starting the project in January 2018, the objectives of this period until February 2020 were to install new receiver station technique at the station’s air chemistry laboratory SPUSO and improving the transmitter station with a conventional vertical antenna on the roof of the *Neumayer Station III*. This has been done in 2 steps: first in January 2019, second in January 2020.

As reported in Hartje et al. (2019), both systems, receiver and transmitter, showed several weaknesses and should be improved during the next summer period (2019 and possibly 2020).

In 2018, an extended receiving and transmitting station was planned and started to be built up. Because the receiver construction was very complex, it could not be completed in time for dispatch. For the transmitter a more powerful replacement was realized. Especially the GPS system for the synchronization of the transmitter could be improved.

Fieldwork

In January 2019 the transmitter was equipped with an improved GPS antenna. Furthermore, a remote control for the transmitter is missing. Due to the new receiver system not being available in time, only one more simple receiver based on Red Pitaya could be connected to the antenna systems of SPUSO. For this replaced receiver also a preamplifier was missing so that the sensitivity was relatively low.

The receiver installed at the beginning of 2018 could still work as planned and very reliably. During 2019 parameters could be set and corrected on both receivers systems by remote maintenance. However, the receiver installed as a replacement system lacked access to GPS signals, so that it could not work very constantly in frequency and time.

Due to these shortcomings, it was decided to run the beacon in receiving mode FT8 on the additional receiver on a trial basis only. In October 2019 some important parameters for the time synchronization could be improved, so that the system could record more reliable reception data from November 2019 until the beginning of January 2020.

In 2019, however, the replanned new receiver system was completed and could be shipped in time. It serves as a complete replacement of the old receiver system from January 2018.

This new receiver system in principle is shown in Fig. 4.10.1. The figure shows three identically constructed Red Pitaya with two preamplifiers for both receiver channels of each Red Pitaya. All three Red Pitaya are synchronized with GPS for time and frequency stability.

In addition, two further small computers (Raspberry Pi 3+ and Banana Pi M3) are installed. While the Banana Pi with 8 cores allows higher computing power, it serves to combine the receiver results of all three Red Pitaya systems. The somewhat weaker Raspberry Pi 3+ takes over an important control task. Should one of the other computers not be able to boot after a very unlikely power failure in the SPUSO, it is possible to access the 3 Red Pitaya via a direct debug interface and check it if necessary.

In order to connect the two currently available triangle antennas to the 6 preamplifiers of the Red Pitaya, an additional buffer amplifier has been inserted. Thus, the long antenna cables are terminated with the characteristic impedance and all receiver inputs can be fed with the antenna signals decoupled in parallel.

While the first receiver, which was installed in January 2018, had been equipped with an operating system version specially prepared for WSPR reception, the 3 Red Pitaya in the new receiver have been equipped with a standard operating system with additional programs.

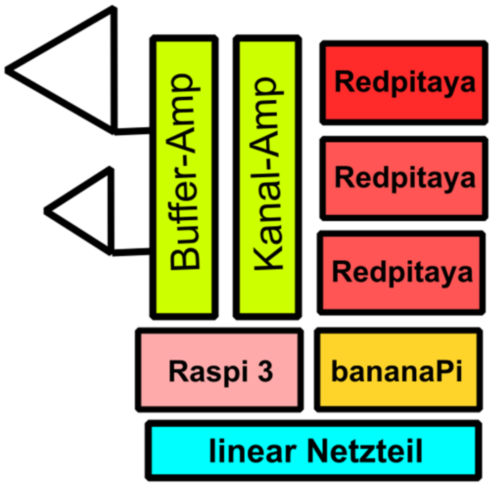

Fig. 4.10.1: Overview of the new installed receiver system

The Raspberry Pi 3+ provides network storage for the new receiver system at *Neumayer Station III*. This allows the unfiltered receiver results to be stored permanently and much more securely locally. At the same time, the current reception results continue to be entered every 2 minutes on the globally available database wsprnet.org.

Fig. 4.10.2 shows the opened housing of the new receiver system. 6 antenna sockets and a connection for the GPS active antenna are clearly visible on the front panel. In the rear left corner of the housing an Ethernet hub is visible, which connects all systems to the network. In the right half of the rear housing the 3 Red Pitaya are hidden. In front of them is a separate metallically well-conductive shielding. Inside the shielding the 6 preamplifiers are mounted.

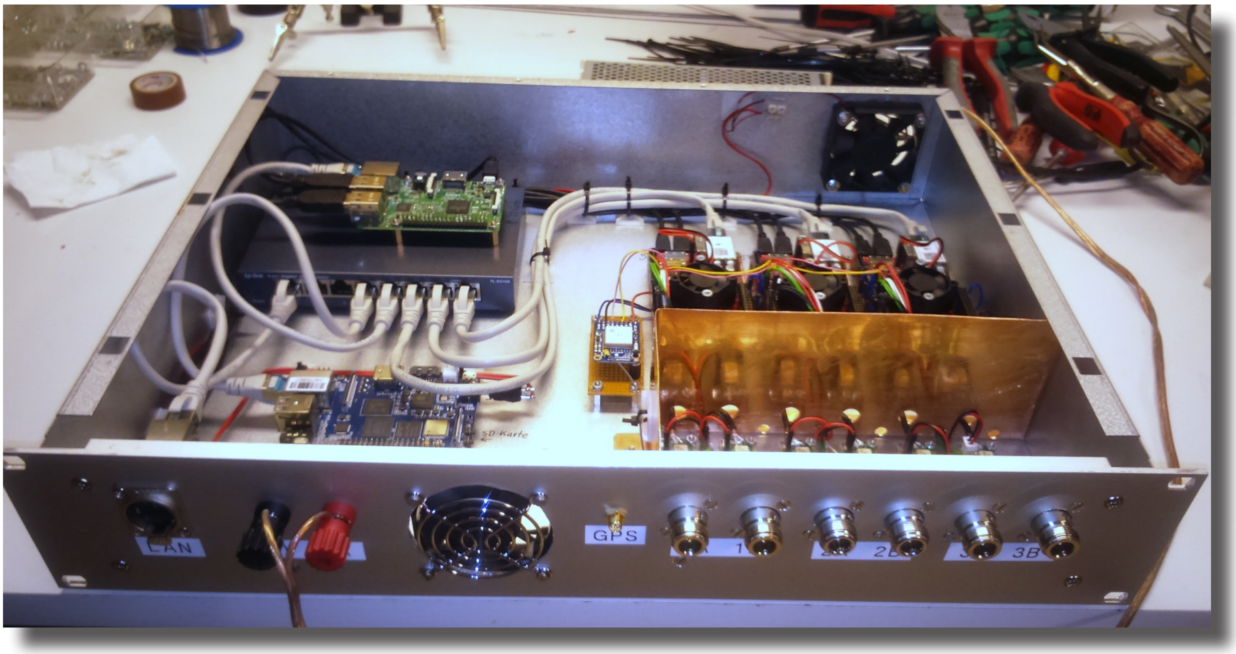

Fig. 4.10.2: Photo of the open new receiver system

At the same time, a new transmitter with a more powerful output stage based on a Red Pitaya became fully remote-controllable in 2019. This new transmitter was installed in January 2020 as a complete replacement for the previous transmitter system. This “second generation” WSPR beacon transmitter at *Neumayer Station III* was designed to add the following features:

- transmission on all eleven shortwave amateur radio bands plus the 50 MHz band (the first-generation transmitter was limited to just five bands)
- controllable and maintainable via remote access
- capable of generating the same RF output power on all bands
- continuous measurement of input and output power, antenna matching and system temperature.

The new transmitter follows the Software Defined Radio principle. The RF signal generation and modulation are done by software. Power amplification and signal filtering continues to be an analog system. The transmitter design is based on the work done by the “Charly 25 SDR” group (Charly-25-group) which also supports the project with hardware and assistance.

The now available power amplifier of the new transmitter can generate up to 20 watts of continuous RF output power, even under poor antenna conditions. However, during normal operation, only about 2 to 3 watts of RF output power are used depending on the frequency. The actual output power is reported into the transmitted information.

For better radiation on the lower frequencies, a 20 m single ended wire antenna was installed on the roof of *Neumayer Station III*. A 9:1 broadband transformer is used for the antenna input for matching.

During sunspot minima an improved propagation on the bands of long and medium wavelengths can be observed. We plan to install the necessary receiver antenna during the upcoming working period, as a first attempt with a special antenna in January 2020 was not successful.

Preliminary (expected) results

During the period of use from late February 2019 until end of January 2020 the WSPR-receiver system showed a good and very reliable performance of the antennas as well as with the remote-controlled receiver system. The additional receiver, which was only installed as a temporary system for testing, did not show stable behaviour. Several changes to the configuration were required by remote maintenance. A permanent success of these experiments became evident not before October 2019, when the continuous reception of FT8 signals was possible. FT8 signals are intended for a bidirectional exchange of short standardized messages. At the same time, they allow digital decoding of signals far below the receiver noise. Receiving characteristics are given in signal-to-noise ratio.

Fig. 4.10.3 shows the geographical distribution of 297 FT8 transmitting stations received during one hour from 21 to 22 GMT on 22 February 2019 at DP0GVN in the SPUSO. The different colours indicate different frequency bands. The dark grey area indicates the night.

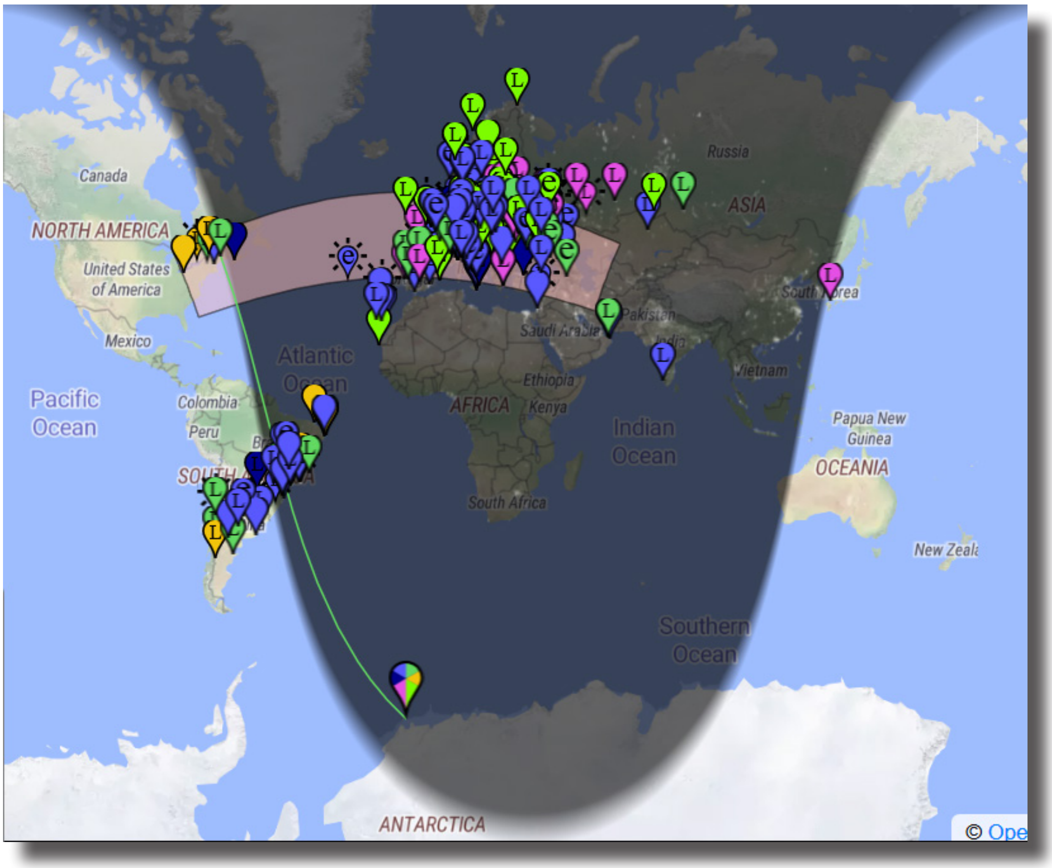

Fig. 4.10.3: received FT8-transmitters on 6 bands during 1 hour on February 22th 2019

In November 633871 and in December 731211 FT8 transmissions were received. These transmissions are of a duration of 12 seconds. All transmissions received in parallel and simultaneously on eight frequency bands were counted.

It can be clearly seen in Fig. 4.10.4 that during the hours between 6 pm and 6 am GMT significantly more emissions could be heard. It should be noted that the stations use relatively high transmission power levels of unknown amplitude, which are permitted under the terms of their license. Therefore, the absolute values of heard transmissions of only twelve seconds each are relatively high. The differences between the two months are relatively small.

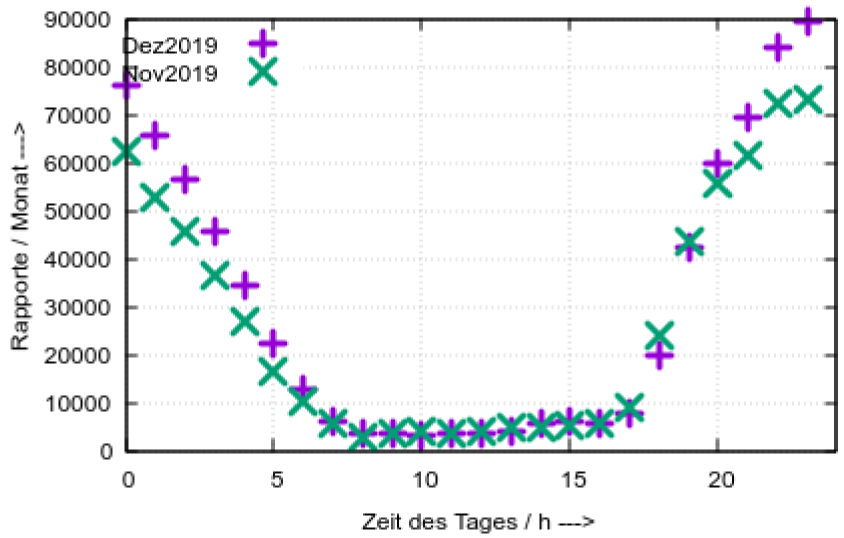

Fig. 4.10.4: Number of received FT8-emissions during month November and December 2019 displayed over hour of the day

With the old (2018) WSPR receiver, receiver spots could be obtained continuously from the day of installation until the day of replacement. Table 1 shows the comparisons of exemplary two months, November and December 2018 and 2019, as well as a comparative representation resolved to the hours of the day in Fig. 4.10.5 and Fig. 4.10.6

Tab. 4.10.1: Number of spots during 1 month in 2018 and 2019

Month	2018	2019
November	106.988	127.346
December	135.691	152.021

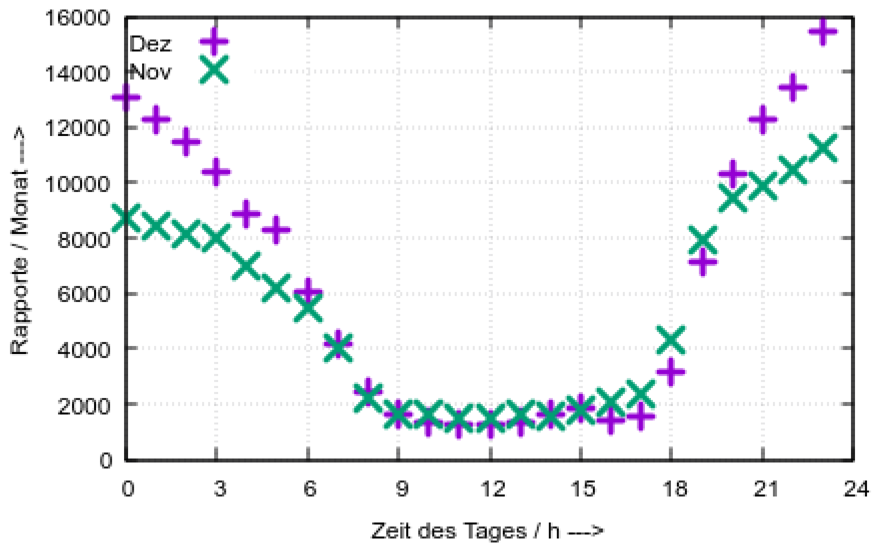

Fig. 4.10.5: Number of spots during month November and December 2018 displayed over hour of the day

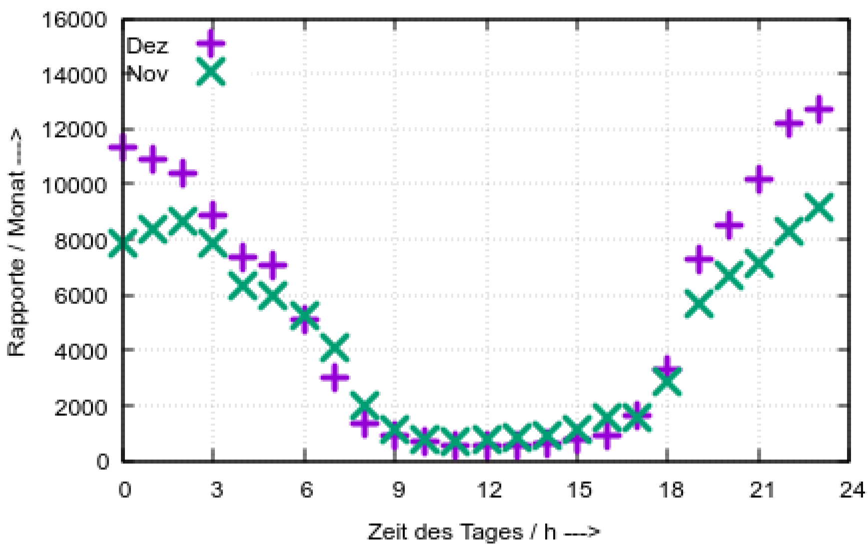

Fig. 4.10.6: Number of WSPR-spots during month November and December 2019 displayed over hour of the day

Fig. 4.10.5 and 4.10.6 shows the number of spots per hour with 8 different radio bands received at SPUSO. Fig. 4.10.5 shows that in 2018 up to 50 percent more spots were registered during the month of December in the hours between 9 pm and 4 am GMT. In the year 2019 - Fig. 4.10.6 - the difference is much smaller with only up to 25 percent. Similarly, Table 4.10.1 shows that an increase in spots of 19 percent can be observed between November 2018 and 2019. For the month of December, the comparison of the two years shows spots of only twelve percent increase.

It is not yet clear what these different increases are based on.

The new receiver system basically uses two Red Pitaya, each with eight parallel bands to receive WSPR spots. The third Red Pitaya can therefore be used for other experiments.

WSPR and FT8 generate signal reports in relation to the measured interference as signal-to-noise ratio in decibels. The absolute levels of the noise as signal power in dBm per Hz are not determined, at all. However, this is interesting information because it allows the relative signal-to-noise ratios of the spots to be converted into absolute signal levels.

In Antarctica, there is very little interference and all potentially interfering emissions are from transmitters located at a distance of at least 4,500 kilometres.

Thus, the receivers in the SPUSO only generate their own noise, which is superimposed by galactic noise and other, possibly man-made noise sources. Therefore, the third receiver was made to determine the absolute noise in dBm per Hertz using a special program.

Fig. 4.10.7 shows the time domain amplitude curves of the measured voltages from both triangular antennas at 9 a.m. GMT on February 22, 2020. Both input voltages were amplified by 55 dB with the adjustable low-noise preamplifiers. It can be clearly seen that the noise amplitudes were still within the linearity ranges of the analog-to-digital converters in the Red Pitaya.

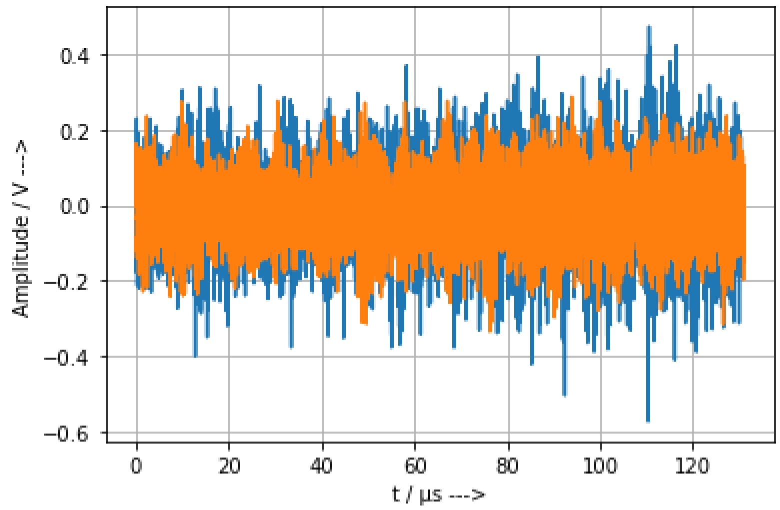

Fig. 4.10.7: measured noise from both triangle antennas amplified by 55 dB

Fig. 4.10.8 shows the noise signal transformed into the frequency domain from Fig. 4.10.7 in logarithmic frequency scale and limited to 30 MHz. In addition, a comparison line is drawn, which was taken from ITU Recommendation (2019). This comparison line indicates the average noise level in a "quiet rural" environment.

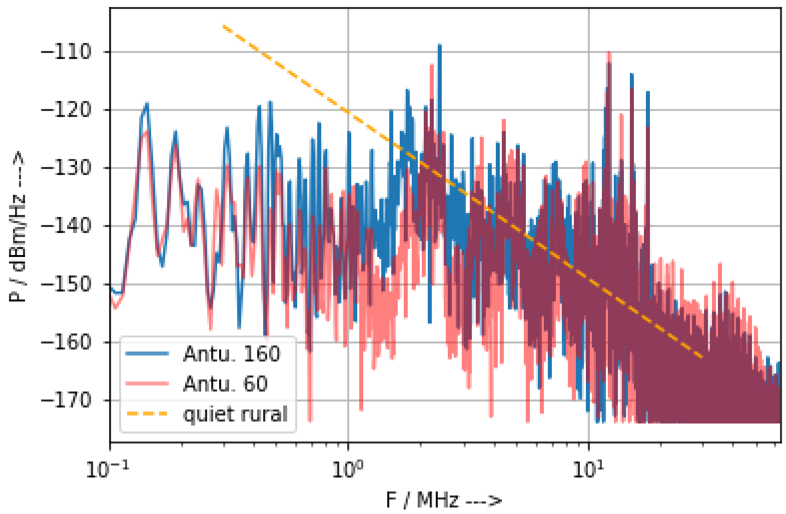

Fig. 4.10.8: Frequency domain of the measured noise power referred to fig. 4.10.7

It becomes clear that at the location *Neumayer Station III* a very low absolute noise level in a worldwide comparison is measured.

Fig. 4.10.8. also shows that above 10 MHz signals from broadcast bands are clearly visible up to about 17 MHz with +30 dB above the noise level. It can also be seen that the different amplitudes of the two antennas (Antu. 160 and Antu. 60) sometimes have more amplitude for a certain frequency range and less amplitude for another frequency range. This can be explained by the resonance properties of the different triangular antennas.

Data management

The data from the receiver is stored locally and on a network storage at *Neumayer station III* as well as fed into a database at wsprnet.org with world wide access. Both offer archive function as well as basic evaluation functionality. The wsprnet.org-archive has collected all received reports since 2008. In June 2019 are there about 1.6 Billion reports ($1.6 \cdot 10^9$) stored. All spots can be downloaded with free access collected monthly to compressed CSV-files.

Conclusion

With the work we have done so far, we have been more than successful in improving the technology of the transmitter and receiver systems. This is an important step during the planned scientific work, as the project involves a long observation and measurement period.

The addition of measurements of absolute noise power from the atmosphere represents an extension of the observations and interpretation originally based on relative measurements.

With the new installed receiver and transmitter system, we can now concentrate more intensively on the observation of propagation phenomena. It is expected that the new sunspot cycle will start this year and radio observations can also be extended up to the 50 MHz band as initially planned in this project.

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Acknowledgement

The two authors are grateful to a large number of voluntary supporters in this project.

Our warm thanks go to Rainer Englert, Christian Reiber and Markus Heller from DARC for setting up and tuning the transmitter and receiver hardware in Germany as well as the Charly-25-Group for the support and sponsoring of the new transmitter system. Special thanks go to Felix Riess, Dr. Matthias Maasch, Andreas Müller, Roman Ackle and several researchers at *Neumayer Station III*, unknown to us, who set up the antennas and commissioned the transmitter and receiver systems with untiring commitment.

4.11 VACCINE – Variation in Antarctic Cloud Condensation Nuclei (CCN) and Ice nucleating particle (INP) concentrations at *NEumayer Station III*

Silvia Henning[1], Rolf Weller[2], Julia Loftfield[2], Marcus Schumacher[2], Frank Stratmann[1] (not in field)

[1]TROPOS
[2]AWI

Objectives

The Earth's current climate is changing more rapidly than has been predicted in most scientific forecasts, with the Polar Regions being the fastest warming areas on Earth. Polar Regions have also a strong global impact on climate conditions and therefore affect lives and livelihoods across the world. Despite the progress polar climate research made, poorly understood processes remain, one of those being the aerosol – cloud – climate interaction, which still cannot be modelled satisfactorily. Clouds and the interactions with the climate system are one of the most difficult components to model, especially in the Polar Regions. This is, besides others, due to difficulties in obtaining high-quality measurements. The availability of high-quality measurements is therefore of crucial importance for understanding processes and for driving and/or evaluating atmospheric models and one of the main objectives of VACCINE. In the ANT-Land 2019/20 season TROPOS extended the existing aerosol measurements at *Neumayer Station III* by *in-situ* Cloud Condensation Nuclei (CCN) and Ice Nucleating Particles (INP) measurements. The captured data such as number concentrations, hygroscopicity, INP freezing spectra etc. will be linked with meteorological information (e.g. back trajectories) and information on the chemical composition of the prevailing aerosol particles for identifying sources of INP and CCN (secondary vs. primary) and transport pathways (local vs. long-range transport) over the full annual cycle. A result of this project will be a deeper understanding which processes dominate the CCN and INP population in high latitudes.

Fieldwork

Starting with the austral summer season ANT-Land 2019/20 CCN-measurements are carried out at the AWI Air Chemistry Observatory with a commercially available CCN instrument (Roberts & Nenes, 2005). With the CCN instrument total CCN number concentrations can be determined as function of supersaturation in the range between 0.1 and about 1 %. The instrument was successfully installed at the Observatory December 13, 2019 (Fig. 4.11.1) and has been measuring continuously since then.

Fig. 4.11.1: Transport of the CCN instrument to SPUSO (left) and after finalized installation and connection to the same inlet as the other aerosol instrumentation (right)

Remote access to the CCN was realized, allowing performance checks of the instrument from TROPOS. The daily / weekly on-site maintenance gets carried out by the overwinterer.

Besides CCN also INP sampling was established, using the low volume filter sampling setup available in the AWI Air Chemistry Observatory (Fig. 4.11.2). These activities aim at the number concentrations of INP in the air, active at temperatures above -25°C. Filter samples are collected on polycarbonate filters and immediately frozen for later analysis in the TROPOS laboratories (Wex et al., 2019). The weekly filter change and handling is done by the overwinterer, as well. These samples are the first ever collected for INP analysis at Droning Maud Land in Antarctica which will span the whole annual cycle. The first set of INP filters just arrived from Antarctica and has therefore not yet been analyzed.

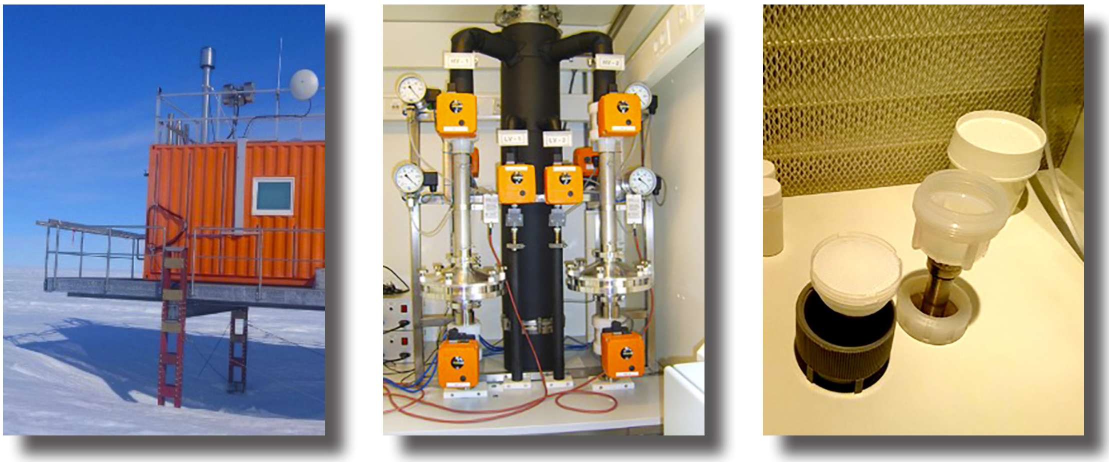

Fig. 4.11.2: Picture of AWI Air Chemistry Observatory at Neumayer Station III with whole air inlet on top (left), the LV sample set-up (middle) and LV filter holder with sampled filter (right)

Preliminary results

The CCN instrument measures CCN number concentrations at 5 different supersaturations (Fig. 4.11.3, lower panel). Combined with the particle number size distribution measurements (Fig. 4.11.3, upper panel), the particle hygroscopicity can be derived (Petters & Kreidenweis, 2006). In our preliminary analysis, comparing Jan 20 to April 20 data, we see a factor 2 higher concentration in the total particle number concentration in Jan 20, but a factor 2.5 to 3 higher CCN concentration, with the largest difference for the lowest supersaturation of 0.1 %. This is accompanied by a factor 4 higher number concentration for the particles larger than 100 nm in summer compared to April 20. New particle formation events were observed in the summer months. Some of them were followed by particle growth into the CCN diameter range. Also, the hygroscopicity parameter is quite different for the two months, with pretty low values ranging in Jan 20 from 0.17 at 0.7 % to 0.47 at 0.1 % supersaturation suggesting a strong influence of organic material for the smaller particles. In April 20 the particle hygroscopicity was on average much higher with 0.4 at 0.7 % to 1.04 at 0.2 % supersaturation which might be caused by an increasing influence of long-range transport to the station.

All results are preliminary and will be followed up by an in-depth analysis including a backward trajectory analysis. A further approach applied for source identification will be the potential source contribution function (PSCF), which is a receptor modelling method that is based on air mass back trajectories. The PSCF (Ashbaugh et al., 1985) has been successfully applied to high-latitude studies in the Antarctic (Dall´Osto et al., 2017). This model is commonly used to identify regions that have the potential to contribute to high values of measured concentrations at a receptor site.

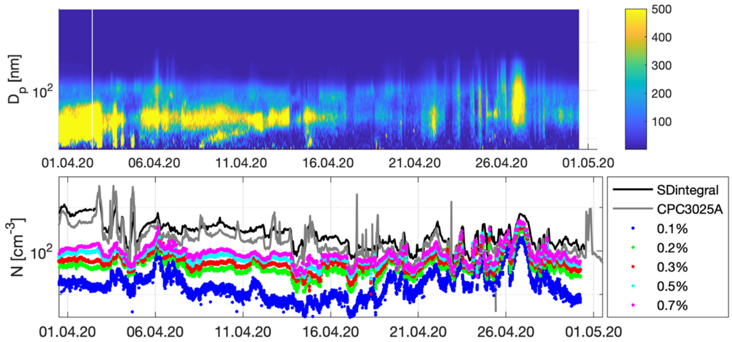

Fig. 4.11.3: Time series of particle number size distribution (top) and the total particle number concentration (CPC3025A, particle diameter >4 nm) together with the number of cloud condensation nuclei between 0.1 % and 1 % supersaturation (bottom) for April 2020.

As the filter samples for the INP analysis have to be transported in a frozen state, they just recently arrived and will be analysed as soon as possible. The INP freezing spectra which will in the further course of the project be linked with meteorological information (e.g. back trajectories) and information on the chemical composition of the prevailing aerosol particles for identifying sources of INP and CCN over the full annual cycle.

Data management

CCN raw data are transferred daily from the instrument to the data server at *Neumayer Station III* and from there to the TROPOS server via cron jobs. After their analysis the INP data will be stored in a long-term archive at TROPOS. Furthermore, the processed CCN and INP data, quality controlled (level 2) data will be publicly available via the open source database PANGAEA data repository (World Data Center PANGAEA Data Publisher for Earth & Environmental Science (www.pangaea.de))

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4.12 EDEN ISS – greenhouse in Antarctica

Vincent Vrakking[1], Daniel Schubert[1], Paul Zabel[1], Conrad Zeidler[1], Markus Dorn[1], Robert Ferl[2], Anna-Lisa Paul[2]

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[2]UF

Objectives

Sustained human presence in space requires the development of new technologies to maintain environmental control, to manage wastes, to provide water, oxygen, food and to keep astronauts healthy and psychologically fit. Bio-regenerative life support systems, in particular the cultivation of higher plants, are advantageous from this regard due to their ability to be employed for food production, carbon dioxide reduction, oxygen production, water recycling and waste management. Furthermore, fresh crops are not only beneficial for human physiological health, but also have a positive impact on crew psychological well-being.

The EDEN ISS project (Zabel et al., 2015) was a 4.5 M€ European Union Horizon 2020 project (reference number: 636501) supported via the COMPET-07-2014 - Space exploration – Life support subprogramme. It had its official kick-off in March of 2015 and ended in April 2019 after the completion of a year-long Antarctic deployment phase in which the EDEN ISS greenhouse system was installed and operated in the vicinity of the *Neumayer Station III*. The EDEN ISS consortium was comprised of leading European experts (in addition to Canada and the USA) in the domain of human spaceflight and controlled environment agriculture (CEA). The EDEN ISS scientific advisory board consisted of the top scientists in the field of space greenhouses from Russia, USA, Japan, Italy and Germany.

The EDEN ISS greenhouse, or Mobile Test Facility (MTF), has been designed to provide fresh produce for overwintering crews at the *Neumayer Station III* in the Antarctic while at the same time advancing the spaceflight readiness of a number of key plant growth technologies. The greenhouse also serves as a tool to develop operational procedures and select science aims associated with remote plant production. The greenhouse consists of two 20 foot high cube containers, which have been placed on top of an external platform located approximately 400 m south of *Neumayer Station III*. The actual system can be subdivided into three distinct sections:

- Cold porch/airlock: a small room providing storage and a small air buffer to limit the entry of cold air when the main access door of the facility is utilized.
- Service Section (SES): houses the primary control, air management, thermal control, nutrient delivery systems of the MTF as well as the full rack ISPR plant growth demonstrator.
- Future Exploration Greenhouse (FEG): the main plant growth area of the MTF, including multilevel plant growth racks operating in a precisely controlled environment.

The design of the EDEN ISS greenhouse is presented in detail in the following publications: Boscheri et al., (2016); Vrakking et al., (2017); Zabel, et al. (2017).

During the 2018 overwintering period, the EDEN ISS consortium tested essential CEA technologies using an International Standard Payload Rack (ISPR) cultivation system for potential testing on-board the International Space Station (ISS). Furthermore, the FEG was designed with a focus on larger scale bio-regenerative life support systems for planetary surfaces (e.g. Moon, Mars). In addition to technology development and validation, food safety and plant handling procedures were, and will be, developed and tested in Antarctica. These are integral aspects of the interaction between the crew and plants within closed environments.

Due to the necessity of validating key technologies for space greenhouses under mission relevant conditions and with representative mass flows, the EDEN ISS consortium defined six objectives:

1. Manufacturing a space analogue Mobile Test Facility.
2. Integration and test of an International Standard Payload Rack plant cultivation system for future tests on-board ISS and a Future Exploration Greenhouse for planetary habitats.
3. Adaptation, integration, fine-tuning and demonstration of key technologies.
4. Development and demonstration of operational techniques and processes for higher plant cultivation to achieve safe and high-quality food.
5. Study of microbial behaviour and countermeasures within plant cultivation chambers.
6. Actively advancing knowledge related to human spaceflight and transformation of research results into terrestrial applications.

Although the project officially ended, the German Aerospace Center (DLR) and the Alfred Wegener Institute (AWI) agreed to continue operation of the EDEN ISS facility at the *Neumayer Station III* through 2020 and beyond.

Fieldwork

ANT-Land 2018/19 Neumayer Station III summer field season

A detailed overview of EDEN ISS related activities carried out by members of the German Aerospace Center, as well as the University of Florida, during the ANT-Land 2018/19 summer season has been documented in the previous year's ANT-Land report (Vrakking et al., 2019).

Nominal Operations Phase – 2019/20 Neumayer III winter season

For the ANT-Land 2019/20 winter field season, operational activities were carried out by the regular overwintering crew. In the absence of a dedicated operator, scientific activities were reduced throughout the season, in an attempt to limit the required crew effort. Remote support was provided by the consortium partners to assist the overwinterers in the operation of the greenhouse.

The EDEN ISS greenhouse was in dormancy between the departure of the EDEN ISS summer team in February and April 2019. No plants were cultivated in that period. First plants were sown beginning of May and consequently transferred into the cultivation trays. The first harvest took place in June 2019.

Most of the time needed for operations was dedicated to nominal operational and maintenance activities, such as:

- Seeding of various crops,
- Transferring juvenile plants from germination area to cultivation trays,
- Pruning/training of fruiting crops, such as tomatoes and cucumbers,
- Harvesting of various crops, starting with rucola on the 11 June, 2019,
- Cleaning and disinfection of surfaces, filters and tanks,
- Exchange of consumables (e.g. filters, oxygen tablets, ozone cells),
- Regular (weekly) tele-cons with remote operations team in Bremen,

- Emptying waste water tanks and refilling fresh water tanks,
- Preparation and exchange of nutrient stock solutions,
- Preparation and exchange of acid and base supply,
- Sensor calibration,
- Cleaning and exchange of misting nozzles in the aeroponic plant cultivation trays, and
- Repair and exchange of pumps.

In total 106,5 kg of fresh food was produced for the overwintering crew between May and November 2019. Valuable knowledge was gained about the operation of the greenhouse with non-specialists and non-scientific personnel compared to the previous winter season during which a trained specialist was conduction the operation. This resulted in improved operation procedures, communication and control software. Furthermore, technical issues were observed that need to be improved in order to optimize the operation of the greenhouse, so that more food can be produced with less resources.

In parallel to the operations on-site at *Neumayer Station III* data evaluation, documentation and publication of the scientific data from the previous winter season were continued by the EDEN ISS partners. Details are provided in a later section.

ANT-Land 2019/20 Neumayer Station III summer field season

During the 2019/20 summer season two project members from the German Aerospace Center travelled to the Antarctic to carry out maintenance and repair work, and to install upgrades to the facility. Although the focus was primarily on routine activities, such as cleaning, sensor calibration, filter exchange and training of the overwintering crew, a number of hardware and software upgrades were conducted as well.

In particular, the misting nozzles in the plant cultivation trays were exchanged with nozzles which have a slightly larger orifice, which should hopefully reduce issues with clogging and cleaning of the nozzles. Additionally, control over the free cooler, the roof-mounted heat rejection unit, was improved by adding control over the fan speed as opposed to the previous on/off control. This measure is expected to reduce the electrical energy demand of the greenhouse.

The EDEN ISS team arrived at the *Neumayer Station III* on 22 December 2019, with flight D9. The last team member left near the end of February 2020. During this time, the following work was carried out with respect to the EDEN ISS project:

- Facility inspection and status documentation,
- Microbial sampling within the facility,
- Harvesting of plants from the Future Exploration Greenhouse (FEG),
- Cleaning of the facility in preparation of maintenance and repair work,
- Cleaning of the Nutrient Delivery System (NDS) piping with hot water,
- Disinfection of the FEG using the TransMADDs system,
- Exchange of consumables (e.g. CO2 canisters, filters),
- Replacement of the gas concentration measurement system of the EDEN ISS safety system,
- Calibration of the newly installed gas concentration measurement system,
- Testing of the EDEN ISS safety system (gas concentration and smoke sensors),

- Preparation of return freight, and documentation, for ship transport to Europe,
- Installation of Argus control software updates,
- Adjustment of settings for imaging system quality and camera positioning,
- Replace damaged/malfunctioning cameras,
- Preparation of nutrient solution for initial plant cultivation,
- Exchange of cooling fluid in the Thermal Control System (TCS) piping,
- Connection of the SES standalone dehumidifier to the condensate water recovery tubing,
- Preparation of plant scheduling for the summer and winter field seasons,
- Organization of newly arrived cargo,
- Initial teach-in of the 2020/21 winter field season overwinterers,
- Initial seeding of the FEG,
- Replacement of the NDS high pressure pumps,
- Exchange of misting nozzles in the plant cultivation trays with larger orifice nozzles,
- Replacement of NDS sensors and calibration of new sensors,
- Replacement of tubing and connectors for NDS acid and base supply,
- Inspection and cleaning of the Atmosphere Management System (AMS) cooling coil,
- Replacement of AMS condensate water recovery loop UV lamp,
- Preparation of nutrient salt mixtures for the winter field season,
- Repair and installation of the AMS cooling coil UV lamp,
- Inventory of consumables and equipment in the MTF, the multi-purpose laboratory and the various storage areas,
- Repair of insulation around the SES window,
- Filming of activities for outreach (e.g. ZDF),
- Backup of data from the 2018/19 winter field season,
- Maintenance on and repositioning of the energy measurement system in the MTF,
- Setup of the PlantCube plant cultivation system in the *Neumayer Station III*,
- Installation of speed control for the free cooler fans,
- Preparation of documents for the winter field season (e.g. procedures, task lists),
- Continued training of the winter field season crew,
- Initial harvesting of crops,
- Modifications to the Power Control and Distribution System with the aid of AWI electrician, and
- Safety briefings for the winter field season crew.

For the ANT-Land 2020/21 winter field season, operational activities will be carried out by the regular winter crew. Remote support will be provided by the consortium partners to assist the winter crew with EDEN ISS-related activities.

Preliminary (expected) results

Detailed analysis of the data and samples from the second operations phase is still ongoing. However, some preliminary results have already been collected and are described below.

Data from the 2018 operations phase has already been published, such as the performance of the Plant Health Monitoring system (Zeidler et al., 2019), the impact of plants on crew well-being (Schlacht et al., 2019), crew time measurements (Zabel et al., 2019), biomass production (Zabel et al., 2020), microbiological measurements (Fahrion et al., 2019), and ISPR plant cultivation system performance (Boscheri et al., 2019). Other data is currently going through the review process prior to being published, one of the topics being the electrical power and energy demand. About 268 kg of fresh edible biomass were harvested between March and November of 2018. A significant amount of fresh biomass was also harvested during the 2018/19 summer season, though this was not tracked as it fell outside of the official operations phase. Fig. 4.12.1 shows the interior of the FEG just prior to harvesting in the 2018/19 summer season in January of 2019.

Fig. 4.12.1: Future Exploration Greenhouse before harvest and cleaning in January 2019

For the 2019 winter season, one objective was to investigate the possibility of running the facility in a stand-by mode for some months and then starting operations remotely. During this stand-by mode, only essential systems were operational, such as the Command and Data Handling System (CDHS) while other subsystems were functioning at reduced capacity.

To allow a remote start of the facility, attempts were made to germinate seeds directly in the plant cultivation trays, as opposed to in a dedicated nursery. Unfortunately, these germination attempts were not successful as the rockwool substrate did not absorb enough moisture from the aeroponic nutrient solution spray. Changes have been made to the design of the 3D-printed rockwool holders to increase the exposure of the rockwool cubes to the nutrient spray, and additional germination tests are planned.

As these germination experiments failed, completely autonomous starting of operations from the remote Mission Control Center was not possible, and the winter crew had to seed plants in the nursery and subsequently transplant them. Nevertheless, the facility ran in a reduced mode between February and May of 2019 and was then successfully switched to nominal operations mode without issue.

In the initial plant cultivation phase during the 2019 winter season, a large accumulation of microbial contamination occurred, which required a significant crew effort for additional cleaning and decontamination measures. As a similar contamination occurred early on during the 2018 winter season, also following an in-depth cleaning and sterilization process, it is assumed that this rapid growth is due to the reduced microbiome diversity after the cleaning, allowing one or a few micro-organisms to multiply without competitor organisms. Once the plants in the facility reached a higher maturity, the issue resolved itself and microbial contamination was greatly reduced, probably because a stable microbiome was reestablished.

During the 2019/20 summer season the cleaning procedures were adapted, to reduce the use of chemicals during cleaning of the Nutrient Delivery System piping, with the assumption that this would allow the existing microbiome to survive, thereby preventing the initial higher level of contamination which had been observed previously. Based on initial observations, this assumption has been validated.

Biomass production

Table 1 shows the amount of biomass harvested each month during the 2019 operations phass. As mentioned previously, the facility was put in a standby mode until May of 2019, at which time the first seeds were germinated. First harvest occurred in June and the last harvest occurred in November. In preparation of the 2019/20 summer season, only part of the available cultivation area of the MTF was used during the months of October and November in order to reduce crew time demand even further. In total, around 106,5 kg of fresh edible biomass was harvested.

Tab. 4.12.1: Monthly fresh biomass harvest during the 2019 winter season

Month	Biomass Yield [kg]
June	4,87
July	14,74
August	25,29
September	26,67
October	23,97
November	11,02

Based on feedback from the first operations phase in 2018, the variety of cultivars available for cultivation in the MTF had been greatly increased for the 2019 winter season. However, for many of these new cultivars no laboratory testing had been done to determine optimal growing conditions and as such some of the new crops did not yield significant edible biomass, thereby reducing the average yield per cultivation area.

Crew time

For the 2019 mission, the overwintering crew of the *Neumayer Station III* was asked to track the amount of time which was spent on activities related to the operation of the MTF. These activities included regular communication with the project team at DLR, nominal operations in the facility such as cleaning, seeding and harvesting, as well as off-nominal activities in case of, for example, component failures. The maximum amount of time needed by the crew per month during the 2019 winter season was 102,5 hours during both July and August. For the other months, the time was less either due to a reduced amount of plant handling activities and/or fewer off-nominal events.

Only a rough time tracking was carried out during 2019, but for 2020 a Timeular time tracking system has been acquired to improve the precision of the measurements.

Crew time was also tracked for remote operations by the DLR team. Activities carried out by the remote operators involved regular communication with the on-site operators, as well as preparation of the 2019/20 summer season by ordering spare parts and consumables, and preparing logistics and relevant documents for transport to the Antarctic. A maximum of about 50 hours were needed for remote operations in August of 2019.

Microbial contamination

Throughout the first operations phase, samples were taken of harvested biomass, and probes were taken from different surfaces and liquids within the EDEN ISS greenhouse, as detailed in the report for last year's activities (Vrakking et al., 2019). During the ANT-Land 2019/20 winter field season, no microbial investigations were carried out, to reduce crew time demand for the winter crew. In case of visible contamination, the crew photographed the contamination for analysis by the experts, before cleaning and disinfecting the affected area.

As part of the activities carried out in the ANT-Land 2019/20 summer field season, the team from DLR took a number of samples from within the MTF to enable analysis after return to Europe. The results of these investigations are not yet available.

Psychological investigations

Due to the limited winter crew size of 10 people, the psychological investigations, carried out in 2018, to determine the impact of the greenhouse and fresh produce on crew wellbeing did not yield statistically significant results. Based on anecdotal evidence the general impact of the greenhouse was found to be positive, and in particular the olfactory experience within the greenhouse was explicitly mentioned as a positive aspect.

The ANT-Land 2019/20 winter field season crew participated in a number of psychological and medical investigations and studies. Results from these investigations should add to the data previously collected and allow for more accurate and significant determination of the impact of the EDEN ISS greenhouse on crew wellbeing. Further investigations are planned for future overwinterers as well.

Data management

All data collected and generated by this project will be published in open access journals and/or submitted to a public database (https://zenodo.org/communities/edeniss).

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4.13 ISO-ANT – Water vapour isotope research in the Antarctic

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Objectives

Stable isotopes of water are fundamental for the understanding of the modern hydrological cycle and key parameters for the reconstruction of past climate changes, e.g. from Antarctic ice cores. For several decades, related isotope research projects had ben focussed on snow and ice samples as end member products of the hydrological cycle, only. Vapour measurements in the field were most difficult to perform. Since very recently, it has become possible to measure the isotopic composition of water vapour with necessary precision by commercially available light-weighted cavity-ring-down spectrometers (CRDS). The CRDS allow that the isotopic content of the water vapour in the air can be analysed directly under *in-situ* conditions on any place or platform almost autonomously, thus also at remote stations in the Arctic or Antarctic.

The overall goal of the project Iso-Ant, funded by the Helmholtz Climate Initiative Regional Climate Change (REKLIM), is a first-time detailed detection and description of the isotopic composition of water vapour transported to the vicinity of AWI's *Neumayer Station III*. In combination with correspondent isotope measurements on board of *Polarstern* and the well-established long-term isotope measurements of snow samples from *Neumayer Station III*, these new isotope measurements will allow a unique simultaneous data set of $H_2^{18}O$ and HDO directly above the ocean surface and after transport to the Antarctic continent. Observational data will be paired with complementing climate simulations using atmospheric circulation models enhanced by explicit water isotope diagnostics. Combined analyses of model results and measured data will provide an improved basis to understand Antarctic climate variability and its imprint in firn and ice cores.

Fieldwork

During the campaign ANT-Land 2016/17 a CRDS instrument was successfully installed at *Neumayer Station III*. Since the installation of the instrument, automatic, continuous isotope analyses of the atmospheric water vapour at *Neumayer Station III* in Dronning Maud Land, Antarctica, have been conducted. During the field season of ANT-Land 2019/20 necessary maintenance work on the instrument was done. This includes the exchange of spare parts and re-calibration of the instrument to ensure the automatic, continuous isotope analyses of the atmospheric water vapour for another 12 months, at least.

Preliminary (expected) results

Combining the results of isotopic measurements in vapour with meteorological data and climate simulations using the atmosphere general circulation model with explicit isotope diagnostics ECHAM5-wiso enable a unique quantitative assessment of the isotopic signature of the Antarctic water cycle. First analyses results, that were submitted as a scientific research article to the journal The Cryosphere, can be summarized as follows:

A first fully-continuous monitoring of water vapour isotopic composition at *Neumayer Station III*, Antarctica, during the two-year period February 2017 to February 2019 is presented. Seasonal and synoptic-scale variations of both stable water isotopes $H_2^{18}O$ and HDO are reported, and their link to variations of key meteorological variables are analysed. Changes in local temperature and humidity are the main drivers for the variability of $\delta^{18}O$ and δD in vapour at *Neumayer Station III*, both on seasonal and shorter time scales. In agreement with previous studies in other regions in Antarctica, in summer, the correlation coefficient between humidity and $d^{18}O$ is higher than the one between temperature and $d^{18}O$ at *Neumayer Station III*. In contrast to the measured $d^{18}O$ and δD variations, no seasonal cycle in the deuterium excess signal d-excess in vapour is detected. However, a rather high uncertainty of measured d-excess values especially in austral winter limits the confidence of this finding. Overall, the d-excess signal shows a stronger inverse correlation with humidity than with temperature, and this inverse correlation between d-excess and humidity is much stronger for the cloudy-sky conditions than for clear-sky conditions.

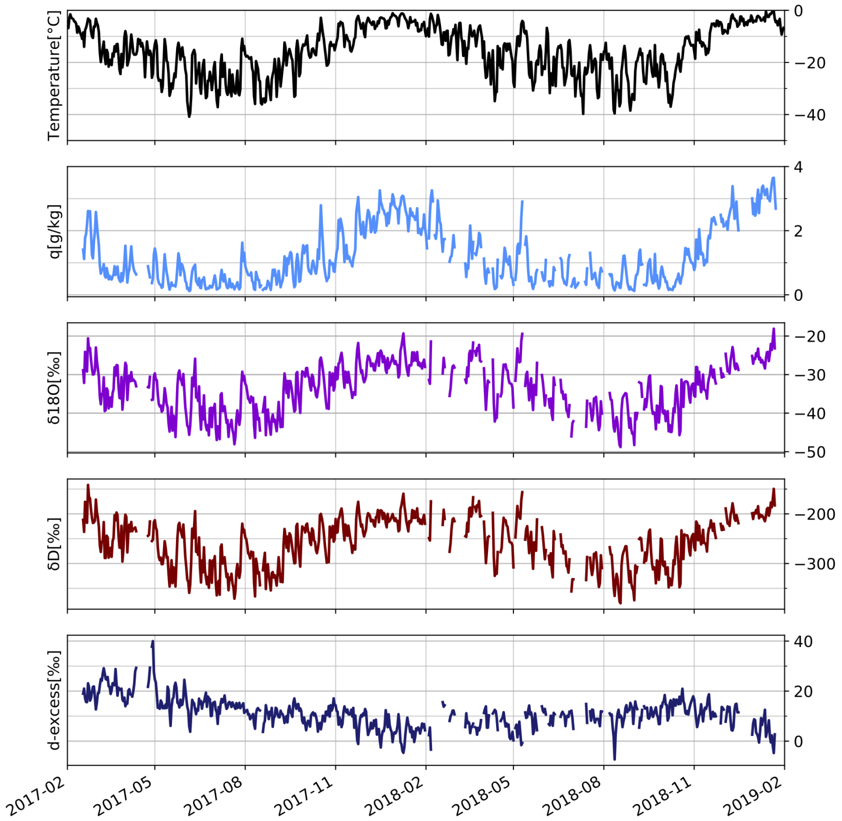

Fig. 4.13.1: Daily averaged observations at Neumayer Station III from February 2017 to February 2019. From top to down: (i) 2m temperature; (ii) specific humidity; (iii) $\delta^{18}O$; (iv) δD; (v) d-excess.

Back trajectory simulations performed with the FLEXPART model show that seasonal and synoptic variations of $\delta^{18}O$ and δD in vapour coincide with changes in the main sources of water vapour transported to *Neumayer Station III*. In general, moisture transport pathways from the east lead to higher temperatures and more enriched $\delta^{18}O$ values in vapour, while weather situations with southerly winds lead to lower temperatures and more depleted $\delta^{18}O$ values. However, for several occasions, $\delta^{18}O$ variations linked to wind direction changes were observed, which were not accompanied by a corresponding temperature change. Comparing isotopic compositions of water vapour at *Neumayer Station III* and snow samples taken in the vicinity of the station reveals almost identical slopes, both for the $\delta^{18}O$- δD relation and for the temperature-$\delta^{18}O$ relation.

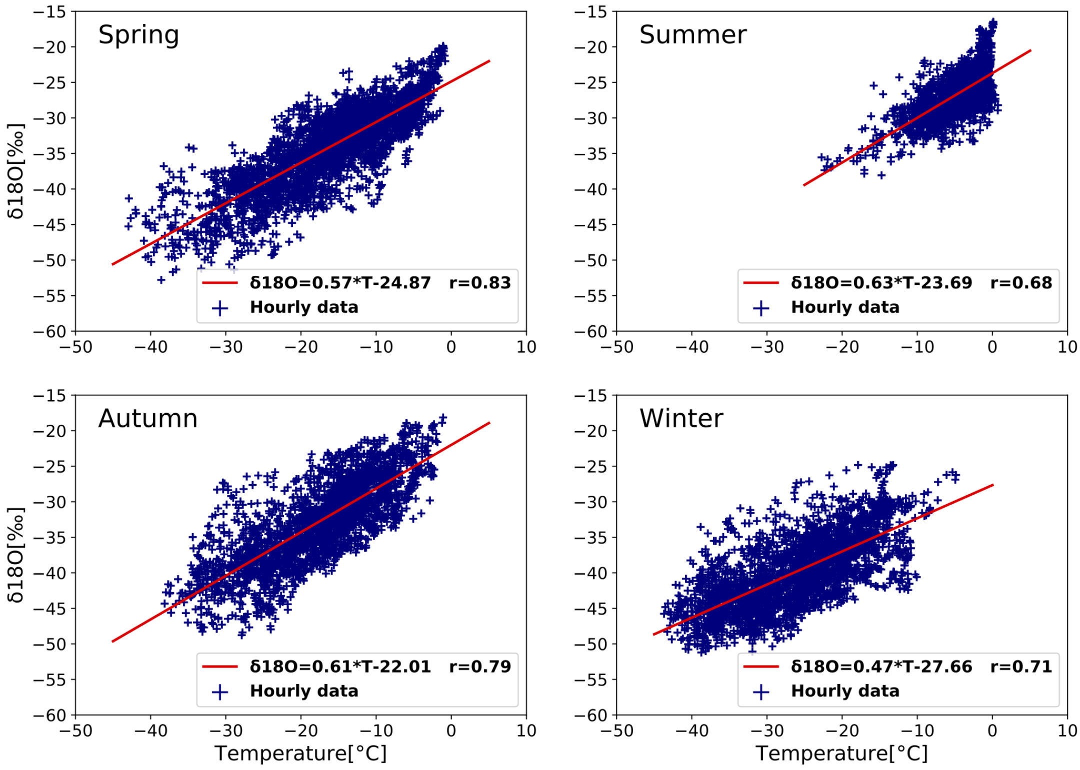

Fig. 4.13.2: δ¹⁸O versus temperature (hourly average) for different seasons of the year. For each season a linear line for δ¹⁸O and temperature is fitted using the least-squares approach. The correlation coefficient is also calculated and shown for different seasons.

Data management

All data will be stored in the PANGAEA data repository (World Data Center PANGAEA Data Publisher for Earth & Environmental Science (https://www.pangaea.de), after quality control, first analyses and/or publication.

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4.14 MARE – Monitor the health of the Antarctic using the Emperor penguin as a sentinel

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Objectives

Operation of a long-term Emperor Penguin Life Observatory in Atka Bay (on land and at sea) to evaluate the dynamics and trends of this population, and, ultimately, the amplitude of the adaptive capacities of the species.

Despite the pristine appearance of Antarctica, its species and ecosystems are under considerable threat. The main goal of MARE is to assess the vulnerability of Antarctic ecosystems using a sentinel species of Polar Regions: The Emperor penguin (*Aptenodytes forsteri*), which stands at the forefront of the impacts of climate warming. Up to now, the general biology of the entire species (e.g. all the breeding, life-history, and demographic parameters) is based on the monitoring of a single colony: the one of *Pointe Géologie* in *Terre Adélie*, located at about 20 min walking distance to the *Dumont D'Urville Station*.

Yet, to evaluate the overall trend of a species and the amplitude of its adaptive capacities, it is crucial to monitor over the long-term more than one population breeding in different ecosystems. This is especially true considering that the species is at high risk of extinction in a very near future according to climatic scenarios. In that context, this second worldwide Life Observatory of emperor penguins (started in 2017 in Atka Bay) aims to measure the species' adaptive potential to climate change and associated fluctuations in prey abundance and distribution.

WP1. Life-long monitoring of the birds is performed using Radio-Frequency Identification (RFID). Each year and over several decades, 300 five-month-old emperor penguin chicks from Akta Bay colony (out of the approx. 7,000 chicks present each year at the end of the breeding cycle) are marked with small Passive Integrated Transponders (PIT, Fig. 4.14.1) in order to monitor birds of known-age and -history throughout their life. Microtagged individuals are detected and identified, year after year, with a Mobile Identification System, e.g. antennas temporary deployable on access passageways to birds' breeding sites.

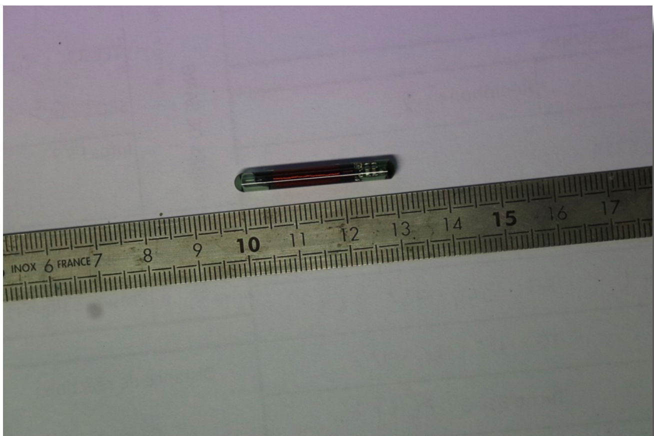

Fig. 4.14.1: Passive Integrated Transponders (PIT) used to mark penguin chicks electronically

WP2. As umbrella species, seabirds play an important role in determining the size for conservation areas. Thus, gathering knowledge on the distribution at sea of the species is fundamental to help us to define and map marine biological 'hotspots' and/or Marine Protected Areas (MPA). Up to know, knowledge of the distribution at sea and of foraging activities and strategies of emperor penguins is scarce and anecdotic, a few individuals from a few (more accessible) populations have been equipped one or couples times. To fill this gap, since 2017, emperor penguins from Atka Bay colony are equipped, over regular intervals and at different stages of their life cycle, with biologgers (TDR/GPS/Argos) to understand how this species uses the space at sea during the breeding/wintering season, their migration, and their wintering at-sea habitats.

In addition, through yearly collection of regurgitate/guano on the ground and stomach content (dead birds, mainly chicks), we aim to determine the geologic provenance of the gastroliths gathered on the sea floor, the diet and trophic level (and their yearly variability) on which they are foraging. Reciprocally, geological contents (pebbles) collected in these samples will improve the geologic characterization of the foraging grounds and thus the glacial-geologic history of the Ekströmisen region (MARGEO project - affiliated to the Sub-EIS-Obs project - was merged in 2019 with the MARE program). Moreover, prevalence and yearly variability of microplastics and contaminants are from now under investigations through the analyses of the stomach contents of these dead birds (collaboration with Dr. Gunnar Gerdts, AWI).

The proximity of *Neumayer Station III* research station to the Atka Bay emperor penguin colony represents a tremendous opportunity to fill these objectives. Moreover, the characteristics of both Pointe Géologie (colony that our team is also monitoring electronically and through camera systems) and Atka Bay colonies are very different regarding numerous aspects, which make the comparison even more valuable to obtain a realistic picture of the health and potential threats for a species, and its adaptive potentialities while facing environmental changes.

Fieldwork

The ANT-Land 2019/20 summer season for MARE program ran from the 04/11/2019 to the 14/01/2020 on the Atka Bay emperor penguin colony (Fig. 4.14.2).

Fig. 4.14.2: SPOT and the Atka Bay emperor penguin colony, November 2019.

From the 27/11/2019 to the 23/12/2020, 300 five-month-old emperor penguin chicks from the colony of Atka Bay were marked with small Passive Integrated Transponders (PIT). Each of these chicks were also measured (flippers and beak), blood sampled, weighted, and temporary marked before release (for not recapturing them another time) (Fig. 4.14.3).

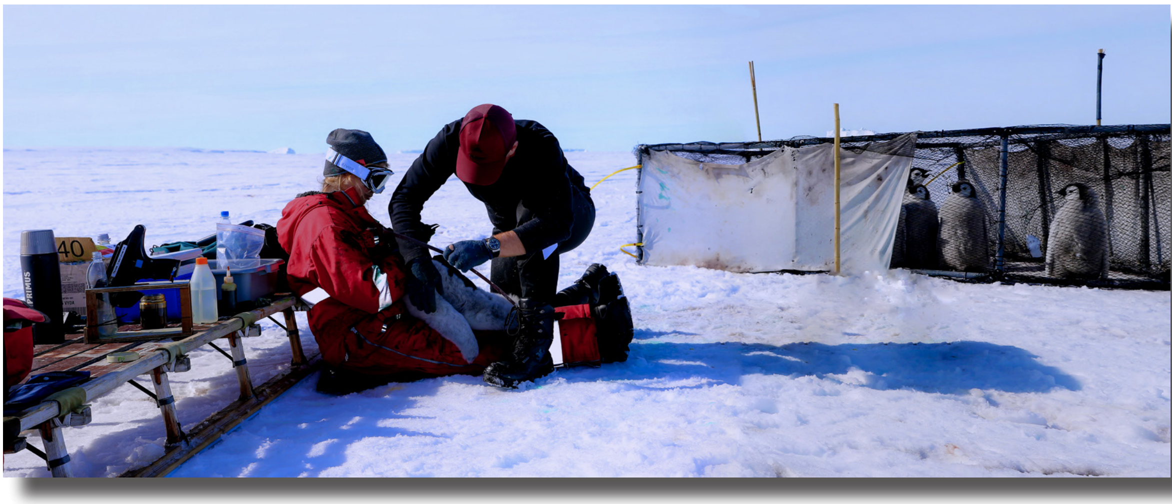

Fig. 4.14.3: PIT-tagging session. Chicks are gathered into a coral (3 panels of 3-meter length that are joined to enclose targeted birds) before the handling.

Three new Mobile Identification Systems have been tested and deployed on the sea ice (Fig. 4.14.4), right after receiving them by *Polarstern* between the 04/01/2020 and the 06/01/2020. These systems will be deployed on the main access passageways of the emperor penguins from the sea to their breeding colony in order to identify previously microtagged birds and start to collect longitudinal capture-mark-recapture data for our population dynamic modelling.

Fig. 4.14.4: First deployments on sea ice of the Mobile Identification Systems.

Colony census (direct and temporal population estimations through SPOT panorama, Fig. 4.14.2), and classical phenological/breeding parameters, chick mortality, and major constraints were monitored over the course of the season. Gastroliths (ca. 50) were found on the sea ice in the vicinity of the emperor penguin colony in Atka Bay. We collected about 4 complete samples of regurgitated material as well as the stomach content from 101 dead emperor penguin chicks.

Preliminary (expected) results

The first on-land objective of MARE Program, which aims to model the population dynamics/trends of Atka Bay colony thanks to the yearly microtagging of fledging chicks and identification through mobile antennas (starting: winter 2020), is based on a long-term data collection (capture-mark-recapture method): age-specific vital traits (survival and breeding success rates) necessary to feed the population models will be available after a minimum of 10 years of electronic monitoring (note that to our knowledge in Pointe Géologie colony, emperor penguins start to reproduce at the age of 5 on average).

Regarding the census of Atka Bay emperor penguin colony this season 2019/2020, an estimation of the population size was done based with photo-panoramas taken:

- the 12/11/2019: 7,176 adults and 5,031 chicks located on the sea ice,
- the 16/11/2019: 461 adults and 1,854 chicks located on the shelf (~ 1-2 km from the sea ice) since the winter. This little sub-colony moved progressively towards the sea ice during January 2020.

Comparatively, 7,640 adults were counted the previous year at the same period (on the 09/11/2018) using SPOT panoramas.

The second at-sea objective of MARE Program, which aims to identify crucial feeding grounds (precious tool for mapping MPAs) and foraging strategies of emperor penguin breeding in Atka Bay and its variability over time thanks to biologging technology, is currently under analyses (Houstin et al. in prep., unpublished data).

Regarding the collection of stomach contents and gastroliths, gastroliths were found in regurgitated material only, not in feces, together with squid beaks, fish eyes and in some cases only partly digested meat or algae. At 95 % the stomach content of dead penguins sampled in November and December were almost empty, with just gastroliths and any or very little amount of food. This result also suggests that one of the main reasons of the Atka Bay chick mortality during this period of the year/breeding cycle is starvation. In this context, chick mortality was really high this year: from the 10/11/2019 to the 13/01/2020, we found 1,251 dead chicks, and no predation events by Southern Giant Petrels (*Macronectes giganteus*) were observed (a mortality which corresponds to 3 times more than during the 2017/2018 summer campaign).

Geological analyses of the gastroliths collected in the 2018/19 season is currently ongoing at BGR. The analysis of 40 stomachs collected in the 2018/19 season is currently being performed at the AWI Helgoland, in collaboration with partners from Switzerland.

Data management

Phenology data, Capture-Mark-Recapture, the composition of stomach contents and the mineralogical composition of the gastroliths will be published in AWI's PANGAEA data repository (World Data Center PANGAEA Data Publisher for Earth & Environmental Science (www.pangaea.de) after completion of the analysis. Data material of the at-sea study (Houstin et al. Submitted) is already archived in AWI's PANGAEA repository (https://doi.pangaea.de/10.1594/PANGAEA.913447).

4.15 MIMO-EIS – Monitoring melt where Ice Meets Ocean – Continuous observation of ice-shelf basal melt on Ekström Ice Shelf, Antarctica

Olaf Eisen[1,2] (not in field), Ole Zeising[1] (not in field), Daniel Steinhage[1] (not in field), Spohie Berger[1] (not in field), Tore Hattermann[3] (not in field), Frank Pattyn[4] (not in field), Noah Trumpik[1], Ina Wehner[1], Edith Korger[1], Josefine Stakemann [1]

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[2]Uni Bremen
[3]NPI
[4]ULB

Objectives

On-ice seismic measurement over the last ten years on Ekströmisen resulted in a mapping of its bathymetry to that extent, that it is now the best known of all ice shelves in the Dronning Maud Land region (Eisermann et al., 2020), only topped by those ice shelves in Antarctica where sub-shelf AUV observations from swath sonars are available. It turned out that the bathymetry of Ekströmisen is much more complex than previously assumed and as currently implemented in all tidal and other numerical ocean models (Smith et al., 2020). Instead of a homogenously flat seafloor, as for instance released in the BEDMAP2 compilation, the bathymetry shows a deep trough in the center of the ice shelf, more than 900 m below the surface of the ice shelf up to 350 m thick. Consequently, it is obvious that all previous ocean model results were not able to consider the correct bathymetry and thus produced results which might be considerably wrong. Coming along with our improved knowledge of the bathymetry, we now have the opportunity to assess the influence of errors and uncertainties in the bathymetry on ocean-modelling results. This would also enable us to predict basal melt rates of Ekströmisen more realistically than possible previously. Such efforts, however, will strongly benefit from direct observations of the basal melt rates on Ekströmisen. In addition, satellite-based estimates of basal melting of ice shelves are highly uncertain (Berger et al., 2020) and widely lack validating/calibrating points. Ground-based measurements of basal melting on Ekström Ice Shelf would therefore offer an invaluable asset to constraint satellite-based measurements. The main research questions of this proposal therefore are:

- How variable are basal melt rates over the course of a year underneath Ekströmisen?
- How are temporal changes in melt rates linked to atmospheric, cryospheric or ocean conditions?
- Can these melt rates reliably be reproduced by a state-of-the-art ocean model when using the new bathymetry?

The method of choice consists of repeatedly measuring the ice thickness with a phase-sensitive radar (pRES). The change of ice thickness over time, under consideration of other effects, basically results in the basal melt rate.

Fieldwork

Initial pRES measurements were made at seven points (EIS-4 to EIS-8 and two additional locations) visited in the ANT-Land 2018/19 season by the Sub-EIS-OBS field party (Wilhelms, 2019) (Fig. 4.15.1). They were remeasured by overwintering personal to derive the mean melt rates over the course of approximately one year.

At the site EIS-7 an autonomous pRES (ApRES) system has been deployed on 2 April 2020 at the location 70.82529°S/8.76275°W (initially in 2018/19 next to the hot-water drill site EIS-7) to provide continuous observations on an hourly time scale over the course of the coming year. It is intended to read out data half-yearly, i.e. once in winter/spring and once in summer/fall. Power supply is provided by a battery (Fig. 4.15.2).

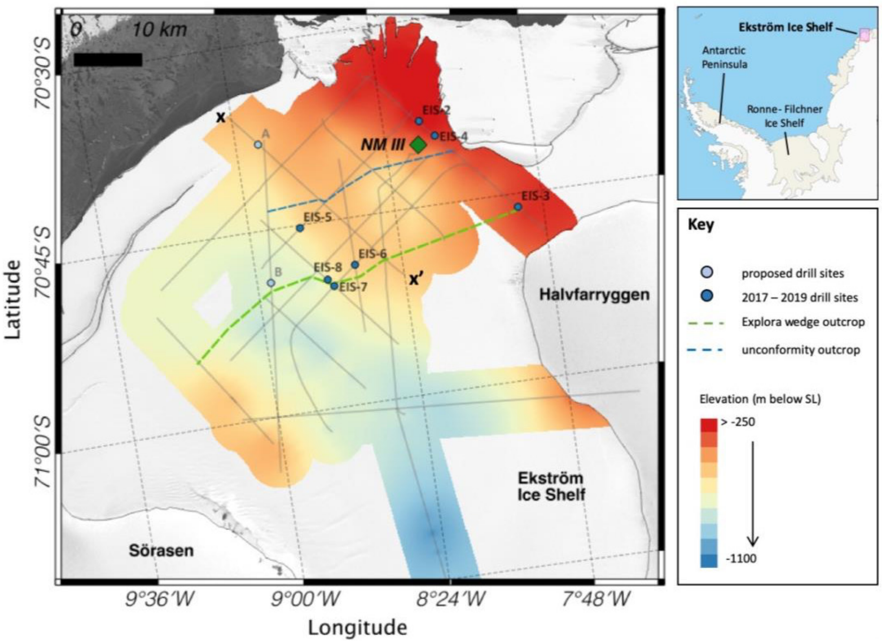

Fig. 4.15.1: Ekström ice shelf with key features indicated. Main map: Ekström ice shelf, the survey area of SUB-EIS-Obs campaign (Wilhelms, 2019). Grey lines indicate pre-site seismic vibroseis data lines (Smith et al., 2020). Colored underlay is sea-floor bathymetry (m below sea level) interpolated from seismic lines. Blue circles are sites where sediment cores have been take (light blue are planned core locations). The seismic line shown in Figure 4.15.2 is indicated by X-X'.

Small map: Location of Ekström Ice Shelf.

Fig. 4.15.2: Deployment of the ApRES system controller and power supply (left) and of the ApRES frame antennas (right).

Preliminary results

Since the deployment the ApRES system has been sending state-of-health messages regularly via an Iridium link in its Eulerian frame of reference. Preliminary analysis of the repeated pRES measurement couples yield melt rates of approximately 0.4 m/a (EIS-5 to EIS-8) and almost 1.9 m/a for site EIS-4 (east of *Neumayer Station III).* Given the low melt rates and rather short time period for repeated measurements the remeasurements in the 2020/21 season have to be awaited before more accurate numbers can be provided.

Data management

After primary publication, the ApRES data will be made available in the PANGAEA data repository (World Data Center PANGAEA Data Publisher for Earth & Environmental Science (www.pangaea.de).

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4.16 IDEP – Impact of Drones to Emperor Penguins

Osama Mustafa[1], Marie-Charlott Rümmler[1], Christian Pfeifer (not in field)[1]

[1]ThINK

Objectives

Impact of drones to emperor penguins

The impact of unmanned aerial vehicles (UAVs) or drones, of which numerous applications in different scientific and commercial fields have led to an enormous increase in numbers in recent years worldwide as well as in Polar Regions, currently is a highly discussed topic. The protection of the pristine wildlife of the Antarctic from such impact seems particularly important and calls for detailed knowledge about the magnitude of disturbances by UAVs. Due to the novelty of the technology only few studies have been done to investigate the impact UAVs have on Antarctic species and those are focused on species of the Sub-Antarctic or the Antarctic Peninsula. So far, no knowledge has been gathered about the sensitivity of emperor penguins to fly-overs by UAVs. In the harsh conditions of the Antarctic continent, energy expenditure becomes an extremely limiting factor to survival and reproduction and thus every disturbance associated with a change in physiology or behavior and thus energy loss becomes crucial. Detailed information about the magnitude of the impact is needed to formulate international guidelines to protect the animals. This project aims to gather the necessary data to address the issue of UAV impact on emperor penguins and to compare the disturbance by UAVs and visitors. Disturbance experiments in different designs have been conducted to measure the impact of UAV operations to emperor penguins. Main questions of this study are:

- At which vertical and horizontal distances are emperor penguins affected by UAVs?
- Does the type of UAV and the breeding phenology of the penguins make a difference to the impact?
- How strong is the impact in comparison to human visitor appearance?

Mapping the emperor penguin colony at Atka Bay

As emperor penguins breed at very remote places of the Antarctic continent data on their population is scarce. UAV represent a promising technology to map colonies of this species precise and very efficient at such remote places (see Mustafa et al., 2017 and Pfeifer et al., 2019). The methodology for data capture and analysis is not yet developed. Goal of this study is to quantify the population of the emperor penguin colony at Atka Bay by UAV-based mapping at different stages of the breeding season.

Mapping snow surface topography in the vicinity of Neumayer Station III

Since the construction of *Neumayer Station III*, considerable snow accumulation has developed in the immediate vicinity of the station building. This is particularly noticeable after storms. In order to quantify the presumed influence of the station body on the wind field, the 3-dimensional topography of the snow surface had to be mapped. During season 2019/20 at *Neumayer Station III* we undertook a series of UAV measurement flights to develop a method for mapping the snow surface topography.

Fieldwork

Impact of drones to emperor penguins

The fieldwork was conducted at the emperor penguin colony of Atka Bay about 7 km from *Neumayer Station III*. During the experiments focal groups of animals were overflown by a quadcopter UAV in two general flight patterns (horizontal and vertical) and various altitudes, ranging from 150 m to 10 m (see Fig. 4.16.1 for the experimental setup). The horizontal flight pattern was applied to the fixed-wing UAV as well. To compare the observed impact with that of traditional field methods, approaches of human "visitors" on ground were conducted. During all experiments, disturbance was observed by using standard video cameras on tripods, in a distance of 100 – 250 m from the observed animals on the shelf in the vicinity of SPOT observatory. The behavior was recorded before, during and after the flights. In an intensive analysis of the video material, behavioral changes are now being examined in detail for adults and chicks (see Rümmler et al. 2016; Mustafa et al. 2017; Rümmler 2018).

Fig. 4.16.1: Experimental setup at the Atka Bay colony. The video cameras used to observe the selected groups of penguins are insulated against cold and wind. Power supply via insulation boxes with heat element. In windy conditions the quadcopter was usually launched and landed manually (left). The fixed wing UAV was activated by throwing it into the air (right)

Mapping the emperor penguin colony of Atka Bay

The emperor penguin colony of Atka Bay was mapped by help of a quadcopter UAV three times during the 2019/20 breeding season (16 Nov, 13 Dec, 31 Dec). During that period the formation of a subcolony at the shelf ice in about 2.5 km distance (WNW) from the main colony was observed (Fig. 4.16.5). This subcolony was mapped three times too (16 Nov, 14 Dec, 31 Dec).

Mapping snow surface topography in the vicinity of Neumayer Station III

In the period November/December 2019 several flight campaigns to map the station area were carried out. Two investigation areas were mapped, one each in the east and west of the station building. The two areas were selected in such a way that the entire area is covered which, at least apparently, is affected by the snow accumulation. A coherent mapping was not possible because no permission to fly over the building was available.

As it is an ice shelf the investigated area is permanently moving. Due to this mobility a comparison of the snow surfaces of different days required the referencing of the mapping results by subsequent transformation using reference points in the terrain (Fig. 4.16.2).

Fig. 4.16.2: Reference point for data transformation

Preliminary (expected results)

Impact of drones to emperor penguins

First preliminary results indicate a reaction of emperor penguins to UAV overflights. For this analysis, changes in stress indicating behaviors are quantified by measuring the proportion of animals displaying vigilance or flipper-flapping (Giese & Riddle, 1999). The reaction is considerably stronger in the chicks than in the adults. Fig. 4.16.3 shows a substantially increase of stress indicating behavior from about the moment of overflight for about 40 – 50 s after the incidence.

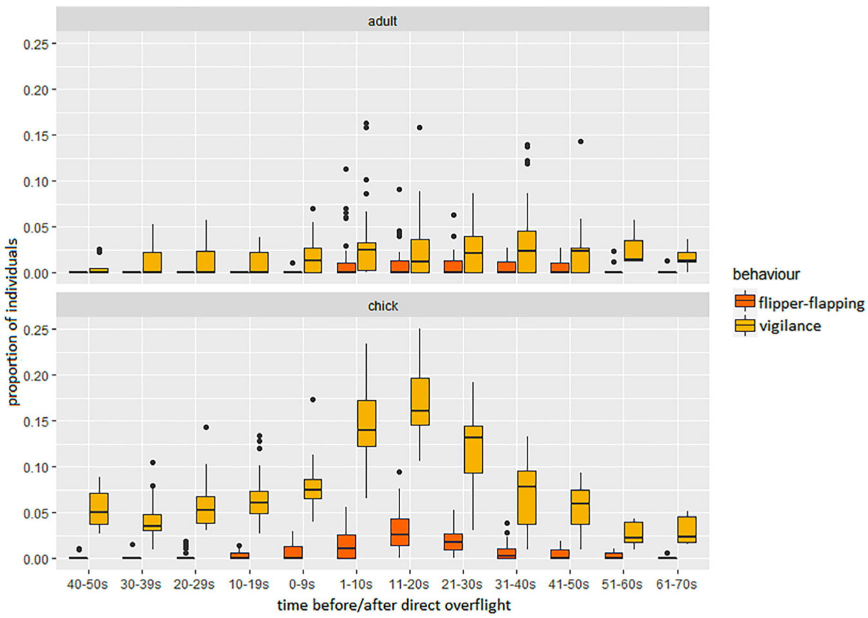

Fig. 4.16.3: Time dependence of stress indicating behaviour of emperor penguin chicks and adults during quadcopter UAV overflights at 20 m a.g.l.

The dependence of penguin stress indicating behaviour on different flight heights is a central question of the study as it is relevant for guidelines and environmental assessment for the design of future UAV missions. First results of vertical quadcopter UAV approaches indicate a distinct increase of vigilance and flipper-flapping at flight heights below about 30 m above ground level (see Fig. 4.16.4).

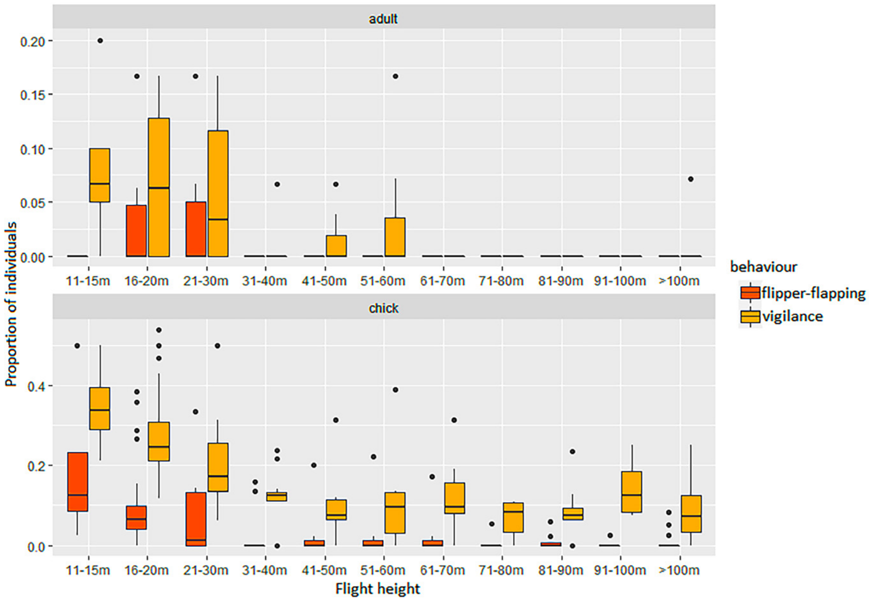

Fig. 4.16.4: Flight height dependence of stress indicating behaviour of emperor penguin chicks and adults during quadcopter UAV vertical approach.

Currently the field data is still being processed and analysed. More results are expected for the application of horizontal overflights in different heights, for the comparison of both UAV models and for the approach of a human on ground. As the experiments were conducted over a period of almost two months insights in changes of the penguin reaction at different stages of breeding phenology are expected as well.

Mapping the emperor penguin colony of Atka Bay

During the UAV-based mapping several hundreds of single vertical images were taken. The single images were processed to an orthomosaic for each mapping campaign (compare Lowe, 2004 and Snavely et al., 2008). As an example Fig. 4.16.5 shows a map with the preliminary orthomosaics of the mapping campaigns at main colony and subcolony at 16 November 2019. With a ground sample distance of 3 cm single penguin individuals can be well identified. Illumination differences in the orthomosaic occur due to changing light conditions during a mapping campaign. Currently the orthomosaics are analysed to derive penguin individual numbers for adults and chicks.

Mapping snow surface topography in the vicinity of Neumayer Station III

For final analysis the data listed in Table 4.16.1 and Table 4.16.2 were chosen as they cover a comparable period for both areas. The final results are five datasets for both of the investigation areas including two RGB orthomosaics, two digital surface models and one dataset on the elevation differences between both models (Fig. 4.16.6).

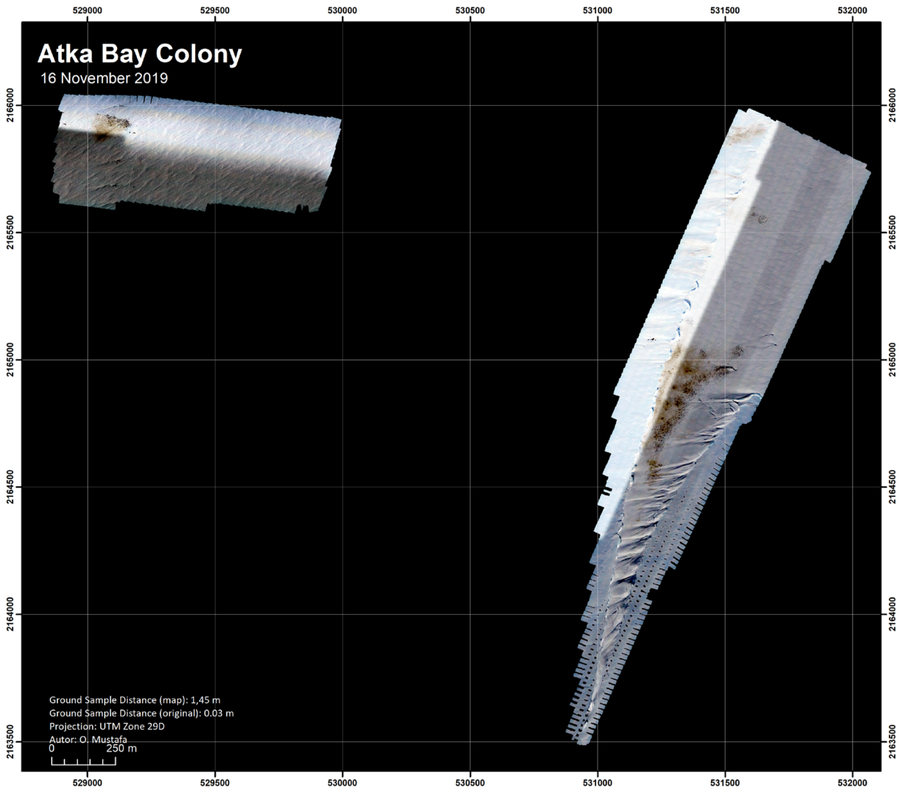

Fig. 4.16.5: Orthomosaics of emperor penguin colony of Atka Bay at 16 Nov 2019

Tab. 4.16.1: Resulting datasets for investigation area East

Description	Date	Area	GSD
RGB orthomosaic	25 Nov 2019	9.2 ha	0.02 m
RGB orthomosaic	29 Dec 2019	9.3 ha	0.02 m
Digital Surface Model	25 Nov 2019	8.8 ha	0.02 m
Digital Surface Model	29 Dec 2019	8.8 ha	0.02 m
Difference of Digital Surface Models	-	8.8 ha	0.02 m

Tab. 4.16.2: Resulting datasets for investigation area West

Description	Date	Area	GSD
RGB orthomosaic	25 Nov 2019	23.9 ha	0.02 m
RGB orthomosaic	29 Dec 2019	23.7 ha	0.02 m
Digital Surface Model	25 Nov 2019	22.2 ha	0.02 m
Digital Surface Model	29 Dec 2019	22.2 ha	0.02 m
Difference of Digital Surface Models	-	22.2 ha	0.02 m

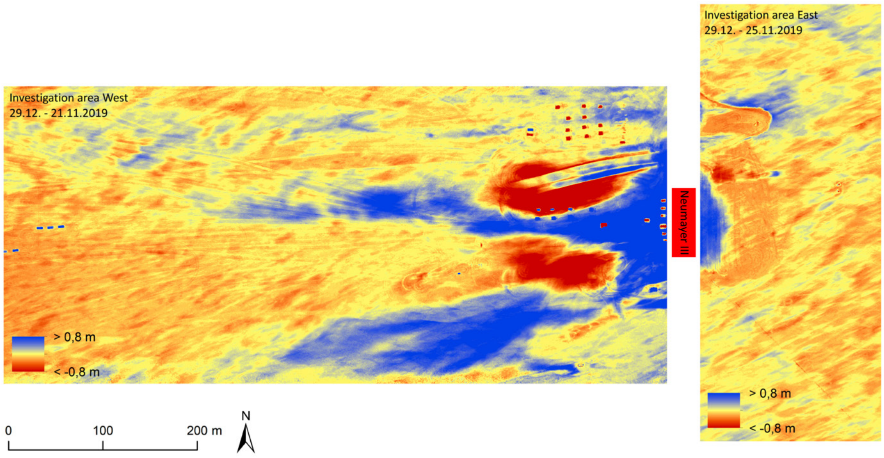

Fig. 4.16.6: Elevation differences between two flight campaigns in November and December 2019 for the investigation areas West and East

Data management

After processing and analysis the collected data will be made available for the scientific community by publication in peer-reviewed journals and/or submitted to a public database. The final datasets on the snow topography are already delivered to AWI.

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4.17. Mumiyo-2 – Late Quaternary environments in Dronning Maud Land inferred from Mumiyo deposits

Sonja Berg[1] (not in field), Eric Buchta[2], Lutz Eberlein[2], Mirko Scheinert [2] (not in field)

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[2]TU Dresden

Sub-fossil stomach oil deposits of snow petrels (*Pagodroma nivea*), so-called mumiyo, form a link between the terrestrial and marine environment (e.g., Berg et al., 2019 a and b). The terrestrial stomach oil deposits record the spatial and temporal occurrence of snow petrel colonies, which is linked to the presence of productive marine foraging areas offshore (e.g., Younger et al., 2016). The deposits can provide evidence for the presence of coastal polynyas, in particular during glacial times (Berg et al., 2019a) as well as on changes in the coastal food web and nutrient availability/consumption (Ainley et al., 2006), which are related to water temperature and origin of water masses in the foraging range of snow petrels. These records have not been widely used so far, however, could provide important information on past polynya activity and marine ecosystem response to late Pleistocene and Holocene climate conditions.

Mumiyo ages older than 50 thousand years before present (ka BP) were found in the mountain ranges of central Dronning Maud Land (DML) indicating snow petrel occupation of these sites during the last glacial (e.g. Hiller et al., 1988; Hiller et al., 1995; Thor & Low, 2011; Berg et al., 2019a). The mumiyo deposits from Dronning Maud Land therefore provide a unique window into the coastal ocean during the glacial and mark this region as an important refuge for Antarctic biota during glacial periods (Thatje et al., 2008).

Objectives

The mumiyo sampling in Scharffenbergbotnen, Heimefrontfjella, provides new material to continue mapping of the temporal and spatial distribution of snow petrel colonies in Dronning Maud Land. While some inland mountain ranges in central DML were occupied by breeding snow petrels since the last glacial, the occupation history of the western part of DML is not well dated. From Scharffenbergbotnen one mumiyo ^{14}C age of 37,400±1500 years was reported, indication that this region was likely also a glacial refuge for snow petrels (Thor & Low, 2011). The samples collected during this expedition will provide new information on timing of snow petrel occupation of the western DML, but also on past changes in the food composition of the snow petrels in concert with changing climatic and oceanographic conditions in the region.

The work program continues previous work of sampling mumiyo deposits from ice-free sites in western Dronning Maud Land, including Heimefrontfjella and Kottas Mountains (Milorgfjella).

Fieldwork

Sampling was carried out at the nunatak group Scharffenbergbotnen in Dronning Maud Land by Eric Buchta and Lutz Eberlein (both TU Dresden) on 3.2.2020. The nunataks were visited along a transect of GNSS measurements carried out by the TU Dresden (see section 4.18). A total of three mumiyo samples were collected from unoccupied nests, respective sampling locations are listed in Table 4.17.1. The nunatak Steinnabben was accessible on foot. Two samples were removed on the northeastern flank of the nunatak (Fig. 4.17.1). The samples are a few cm thick layers of greyish/brownish material and were found in rock cavities underneath large boulders. The nunatak Haldorsentoppen close to the SVEA research station was accessible on foot as well. A large mumiyo sample (c. 20 cm thick) was discovered on the eastern side of the nunatak and removed with hammer and chisel (Fig. 4.17.1). The samples were wrapped in aluminum foil and stored cool and in darkness afterwards. Samples were frozen upon arrival at *Neumayer Station III*.

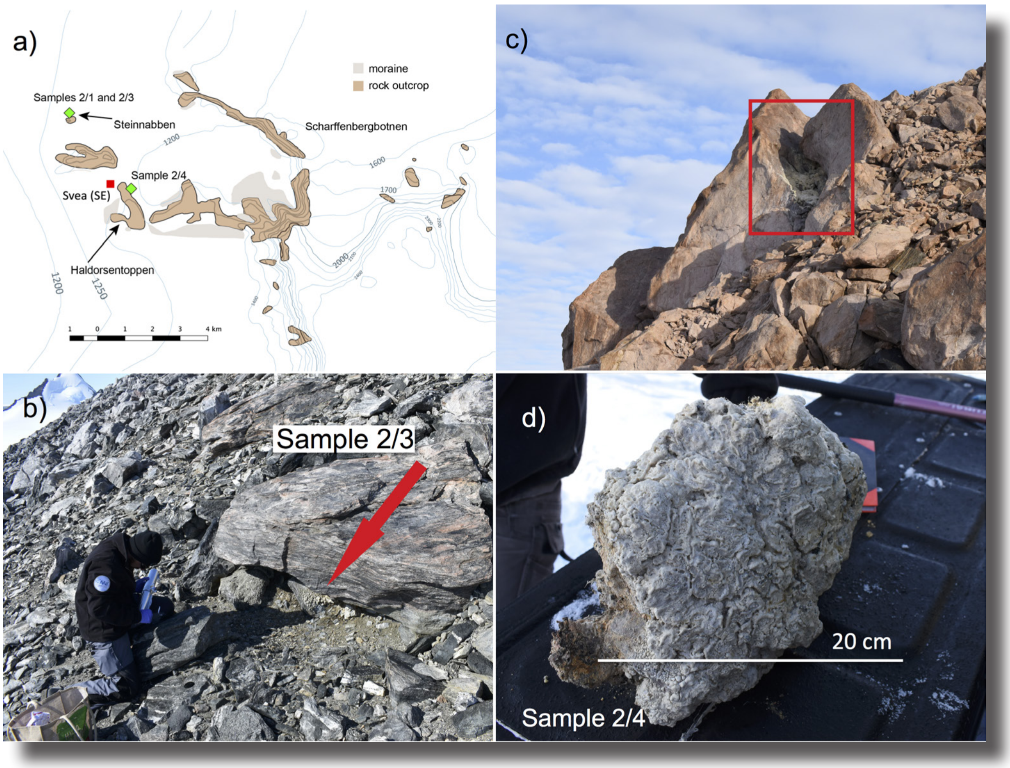

Fig. 4.17.1: Location of the sampling sites at Scharffenbergbotnen, Heimefronfjella, in western Dronning Maud Land (a). Sampling site 2/3 at the north-eastern flank of the nunatak Steinnabben (b). Sampling site 2/4 at the eastern flank of the nunatak Haldorsentoppen (c) and photo of sample 2/4 (d).

Preliminary results

In the surroundings of the nunatak group Scharffenbergbotnen only few snow petrels were recognized. At the nunatak Steinnabben single birds were seen and around SVEA station birds were only observed in larger distances (1-2 km) in steep, rocky slopes. Kottas Mountains (Milorgfjella) were visited as well (see section 4.18). As in the previous season (ANT-Land 2018/19; Fromm et al., 2019), no snow petrels or mumiyo deposits were observed in Kottas Mountains. Further mumiyo sampling was intended on nunataks of the south-western Heimefrontfjella. However, no further occurrences of snow petrels and mumiyo deposits were discovered.

Table 4.17.1: List of samples

ID	Location	Latitude	Longitude	Date
2/1	Steinnabben (STEI)	S 74.5513°	W 11.2759°	03.02.2020
2/3	Steinnabben (STEI)	S 74.5513°	W 11.2759°	03.02.2020
2/4	SVEA Station	S 74.5833°	W 11.2167°	03.02.2020

Data management

Data obtained on sample material will be made available on PANGAEA data repository (World Data Center PANGAEA Data Publisher for Earth & Environmental Science (www.pangaea.de)).

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4.18 DML-GIA – GNSS measurements in Dronning Maud Land to investigate glacial-isostatic adjustment

Eric Buchta[1], Lutz Eberlein[1], Mirko Scheinert[1] (not in field)

[1]TU Dresden

Objectives

Quantifying glacial isostatic adjustment (GIA) in Antarctica is crucial to understand future land and ice-sheet evolution and to correct estimates of ice-mass change from satellite gravimetry (GRACE). A wide range of GIA models have been developed during recent years adopting different modeling approaches. However, substantial differences between GIA model predictions still remain, regarding both spatial pattern and magnitude of vertical uplift rates as well as the magnitude of the continent-wide GIA mass effect (Whitehouse, 2019). Geodetic GNSS (Global Navigation Satellite System) observations on bedrock provide direct observables to constrain these models. However, the coverage of permanent and campaign GNSS sites is quite different over Antarctica due to the availability of bedrock outcrops and depending on logistic conditions. In central Dronning Maud Land (DML), East Antarctica, our group started GNSS observation campaigns already in the mid-1990s. The coverage was extended to western DML in 2001/2002 and 2004/2005. Almost all GNSS sites were set up in the mountain range that stretches nearly parallel to the coast, from Heimefrontfjella over Borgmassivet, Orvinfjella to Wohlthatmassivet, over a distance of more than 1,000 km. Whereas for central DML resulting vertical uplift rates could already be inferred, for western DML this is not the case because only the initial observation campaigns were carried out.

The planned GNSS measurements are part of the ongoing project "*Investigating glacial-isostatic adjustment on basis of geodetic GNSS observation campaigns in Dronning Maud Land, East Antarctica*", funded by the German Research Foundation (SCHE 1426/28-1).

Additionally, a test installation of two permanently operating GNSS stations was accomplished at Weigel Nunatak near Kottas Mountains, and at Forstefjell, about 150 km southeast of *Neumayer Station III*. Permanently GNSS recordings will allow detection of annual and semiannual coordinate changes. Both stations are collocated with seismological stations of AWI.

Furthermore, to optimally use personnel and logistic efforts we realized the following tasks defined by other research projects:

- Measurement at snow accumulation stakes during the traverse towards Kottas Mountains on behalf of AWI Glaciology, see chapter 4.9
- Maintenance of seismology stations of AWI Geophysics at Weigel Nunatak, *SVEA* and Forstefjell
- Maintenance of the permanently operating GNSS station at SVEA (Sweden)
- Mumiyo sampling (project Dr. Sonja Berg, University of Cologne), see chapter 4.17

Fieldwork

The fieldwork was split in two parts covering the two designated work areas.

Working area Heimefrontfjella

During the traverse from *Neumayer Station III* to Heimefrontfjella, 21 to 24 January 2020, we conducted the relative height measurements of snow stakes.

The fieldwork in the Heimefrontfjella region itself lasted from 24 January 2020 to 06 February 2020. The base camp was set up near Weigel Nunatak at 74.27°S and 9.67°W. The geodetic GNSS measurements were planned to cover at least five full days (24h) of observation. Driving from the base camp by Toyota Hilux to the destinations, the GNSS equipment (see Fig. 4.18.3) was installed at the sites KOT1, KOTA, DRAB, STEI, MONS and VARD in the period from 25 to 30 January 2020, see Table 4.18.1. The routes are shown in Fig. 4.18.1. The site RIST could not be reached because adverse ice surface conditions (larger crevasses) prevented a safe drive. *SVEA* station was visited on 28 January 2020, where we checked the GNSS equipment. Due to a dysfunction of the Trimble R7 receiver (originally installed by the Swedish colleagues) it was temporarily replaced by a Novatel FlexPak6 receiver. Further maintenance works have to be coordinated with the Swedish colleagues of KTH Stockholm and can only be planned for future campaigns. Additionally, we performed the maintenance of the seismometer at *SVEA* (on behalf of AWI Geophysics). This included a replacement of the GNSS antenna and the data logger.

The re-collection of the installed GNSS equipment began on 01 February 2020 and was finished on 06 February 2020 resulting in observation periods shown in Table 14.8.2. The second visit at *SVEA* station on 03 February 2020 was used for finishing the maintenance of the seismometer.

From 02 to 04 February 2020 the test installation of the permanently operating GNSS-station at Weigel Nunatak was accomplished (see Fig. 4.18.4).

Tab. 4.18 1: Overview of the coordinates and date of first observation of the GNSS sites

ID	Name	Latitude	Longitude	Ell. height	First observation
KOT1	Weigel Nunatak	S 74° 16’ 29”	W 09° 37’ 20”	1513.3 m	12/2004
KOTA	Windy Corner	S 74° 18’ 00”	W 09° 45’ 25”	1460.0 m	1996
DRAB	Drabanten	S 73° 54’ 10”	W 05° 54’ 47”	2076.8 m	01/2005
STEI	Steinnabben	S 74° 33’ 13”	W 11° 16’ 17”	1328.1 m	12/2004
MONS	Monsrudnabben	S 74° 40’ 50”	W 11° 55’ 13”	1316.5 m	12/2004
VARD	Vardeklettane	S 75° 00’ 45”	W 12° 47’ 07”	1530.5 m	12/2004
RIST	Ristinghortane	S 74° 54’ 30”	W 11° 20’ 14”	2244.6 m	12/2004
KOP1	Weigel Nunatak	S 74° 16’ 29”	W 09° 37’ 20”	1513.3 m	02/2020
FOP1	Forstefjell	S 71° 50’ 09”	W 05° 42’ 21”	-	02/2020

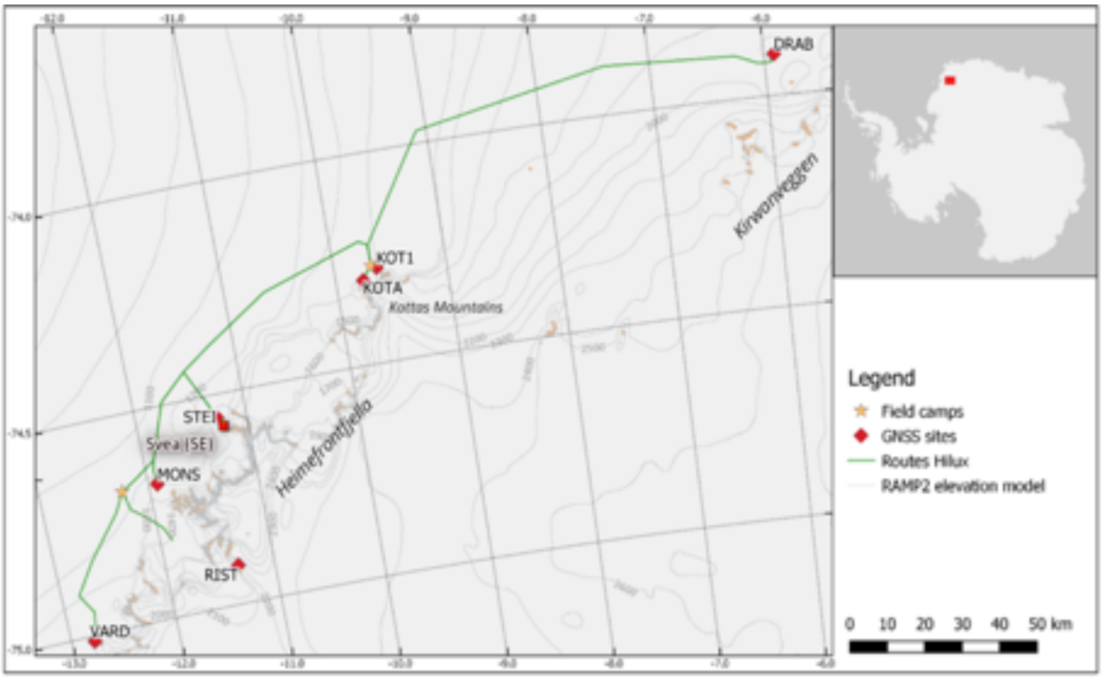

Fig. 4.18.1: Overview map showing the GNSS sites in the Heimefrontfjella region and the routes taken by Toyota Hilux

Tab. 4.18.2: Observation periods of the GNSS sites at *Heimefrontfjella*. Dark blue: full 24 h recordings; light blue: less than 24 h data.

Site/Date	January							February					
	25	26	27	28	29	30	31	01	02	03	04	05	06
KOT1													
KOTA													
DRAB													
STEI													
MONS													
VARD													
RIST	not observed												

Working area Forstefjell

Fieldwork at the Forstefjell was done from 10 to 12 Februray 2020. To reach Forstefjell we could use two Toyota Hilux cars which was optimal in terms of safety and effective temporal utilization. The route from *Neumayer Station III* to Forstefjell (waypoint FF 14) is shown in Fig. 4.18.2. The test installation of the permanent GNSS site FOP1 was carried out from 11 to 12 February 2020. Additionally, the seismometer at Forstefjell (AWI Geophysics) was maintained, including a replacement of the data logger and the seismometer on 12 February 2020.

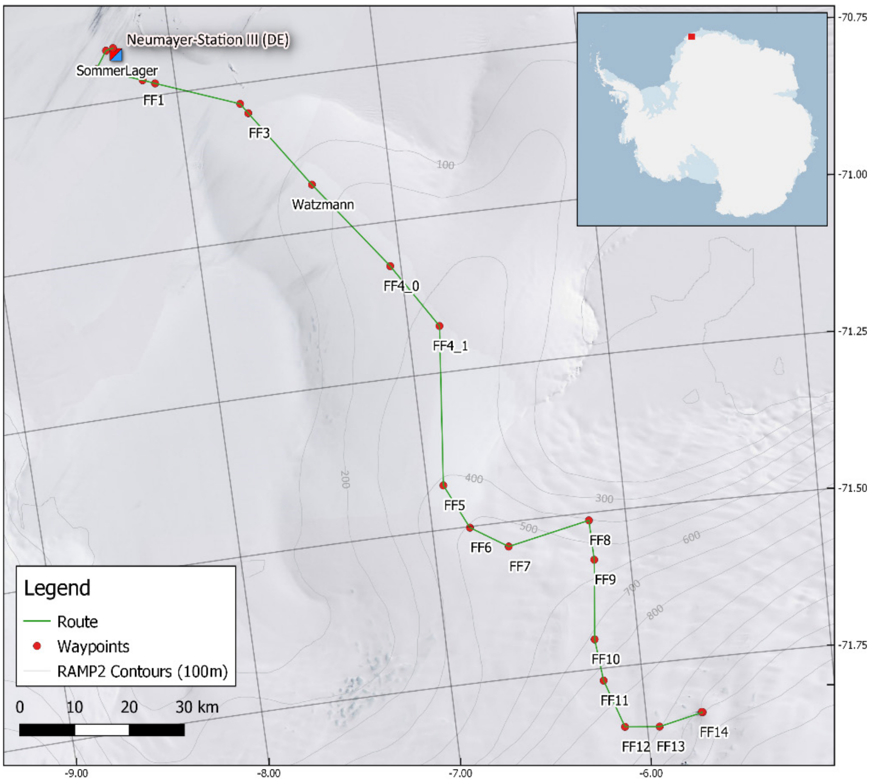

Fig.4.18.2: Overview map of the route from Neumayer Station III to Forstefjell (waypoint FF14).

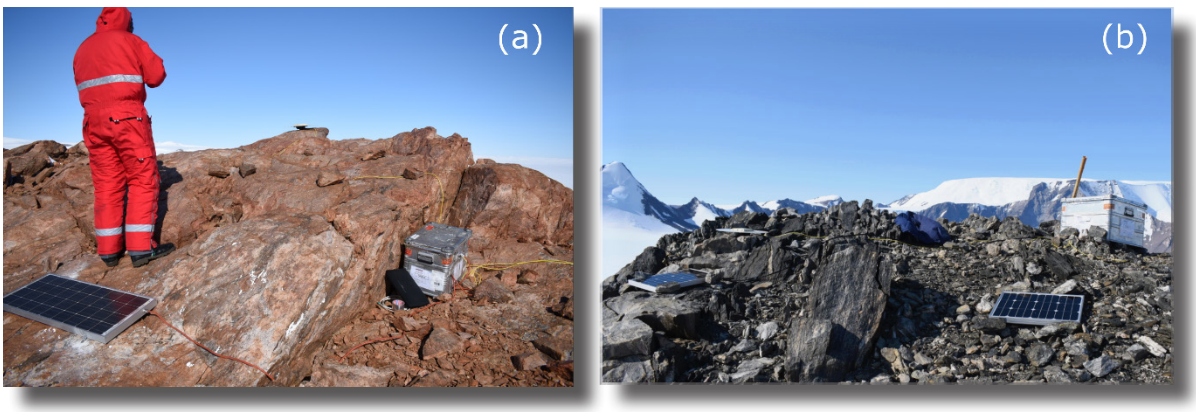

Fig. 4.18.3: The GNSS sites at Monsrudnabben MONS (a) and Steinnabben STEI (b) consisting of a GNSS antenna, solar panels and a zarges box, containing batteries and the GNSS receiver.

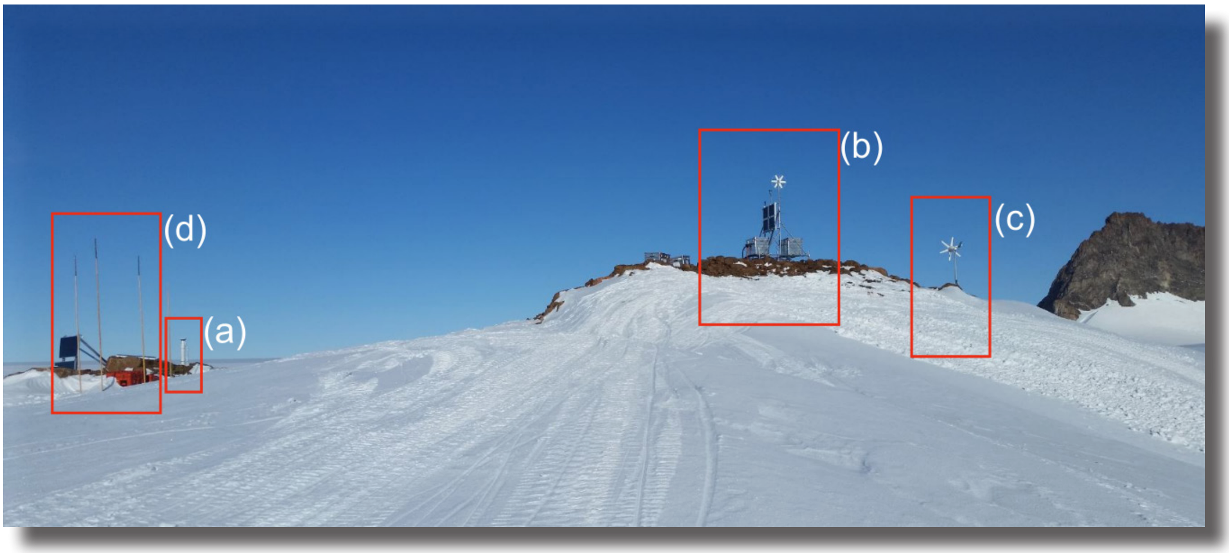

Fig. 4.18.4: Test installation of GNSS site KOP1 at Weigel Nunatak with (a) GNSS antenna on top of pillar, (b) solar panel, first wind generator and box containing receiver and batteries, and (c) second wind generator. The collocated seismometer station (AWI) is situated at (d).

Preliminary/expected results

All GNSS data will be processed at the home institution (post-processing), because precise orbit and clock data as well as observational data of permanent stations of the International GNSS Service are to be incorporated. The data of the two test sites at Weigel Nunatak and Forstefjell will be processed only after it could be downloaded in the 2020/21 or 2021/22 season, since these two sites are working offline. From the processing we expect to infer precise coordinates (with an accuracy of 2 to 5 mm) and coordinate change rates (with an accuracy of 1 to 2 mm/a).

Data management

Original (raw) GNSS data will be archived at the GNSS database of TU Dresden in conjunction with the SCAR GNSS Database. Final data (processed results) will be published at the data repository (World Data Center PANGAEA Data Publisher for Earth & Environmental Science (www.pangaea.de)) in conjunction with a scientific publication.

References

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4.19 MICA-S – Magnetic Induction Coil Array - South

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[3]UNH,
[4]KHU
[5]KOPRI
[6]GFZ

Objectives

The objective is to continuously observe geomagnetic pulsations at *Neumayer Station III*. The geomagnetic latitude of *Neumayer Station III* is ideally suited to investigate so-called electromagnetic ion cyclotron (EMIC) waves near the plasmapause by observing these pulsations. EMIC waves are naturally occurring electromagnetic waves in the near-Earth space that can cause loss processes for particles in the Earth's radiation belts as well as the ring current and are therefor relevant for space radiation processes and risks to spacecraft. They are studied by ground and satellite magnetometers and often in conjunction with each other. Both fluxgate and induction magnetometers can be used, but the latter are preferred. Therefore, the MICA-S induction magnetometer at *Neumayer Station III* is relevant for scientific satellite missions like ESA's Swarm mission, NASA's Van Allen Probes, or JAXA's ARASE (ERG) satellite. Also of great importance is a coordinated ground observation effort at both hemispheres and especially at high latitudes.

Fieldwork

New snow constantly accumulates on top of instrument pit, which therefore becomes deeper over time. Once a year, we remove the upper layer of snow from the wooden plates on top of the pit and reinstall the cover at snow surface. The coils are now approximately 3 m below the surface.

Preliminary (expected) results

Fig. 4.19.1 shows an example of geomagnetic pulsations at *Neumayer Station III* (VNA) and other high latitude stations. It demonstrates both the quality of the data from the instrument installed at *Neumayer Station III* and shows that the signal is to some extent coherent with that at other stations in Antarctica and the Arctic.

Data management

Data (plots and cdf-files) is currently freely distributed through http://mirl.unh.edu/ulf_status.html. Data will also be curated either at AWI or GFZ and will receive a DOI.

References

K-H Kim, H-J Kwon, H Kim, H Jin, J Shin, T Fromm, J Matzka and Lessard M (2019) Local generation of EMIC waves near the plasmapause: Coordinated magnetosphere-ionosphere-ground observations. Asia Oceania Geosciences Society, Annual Meeting, ST23-D5-AM1-308-00.

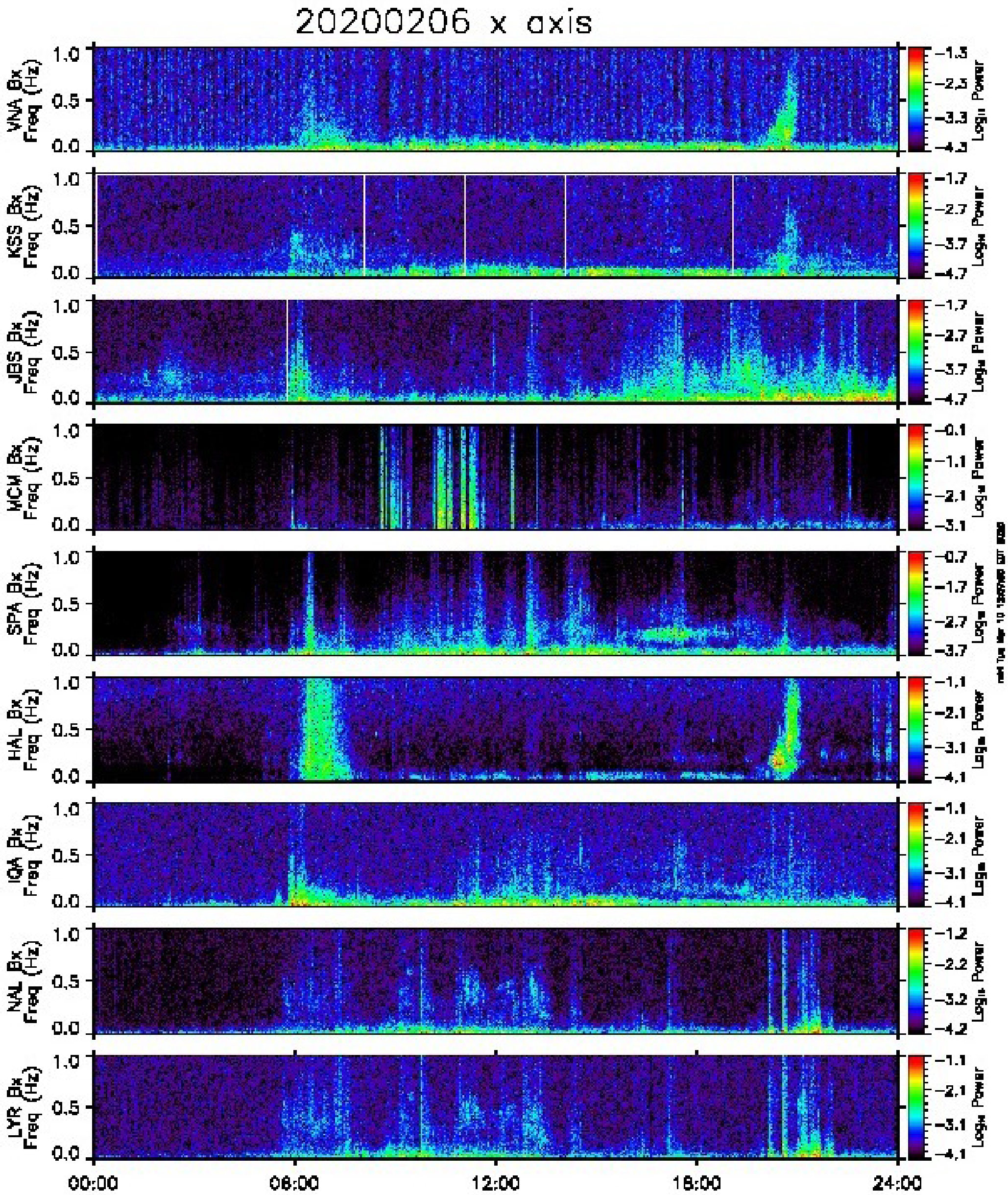

Fig. 4.19.1: Geomagnetic spectrograms for Feb 6, 2020, for 6 Antarctic stations (VNA to HAL) and 3 Arctic stations (IQA, NAL, LYR)

5. KOHNEN STATION

Kohnen Station was closed during season 2019/20.

6. DALLMANN LABORATORY

6.1 Mercury contamination and plastic debris residues in Antarctic petrel species

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Objectives

Global industrial production and consumer behavior lead to increasing contamination of the oceans. Therefore, there is a growing need to understand the prevalence and risk associated with exposure of wildlife to sources of contamination such as plastics and mercury, especially in remote areas such as the Southern Ocean. To compare the exposure to plastics among petrels sampled at different Antarctic and subantarctic sites and times of the season, the presence of three common plasticizers will be determined in the waxy preen oil using a recently established GC-MS (Gas chromatography–mass spectrometry) protocol (Hardesty et al., 2015). In addition, mercury will be measured from the same birds using feather samples which integrate long term exposure and blood samples which are representative of the exposure over the short term (weeks to months). We will focus on small petrels (storm-petrels, prions and blue petrels) and will also analyze samples from storm-petrels breeding in the North-east Pacific to enable a comparison to an area with high plastic exposure. We will test for differences in the level of contamination associated with breeding and inter-breeding distribution and trophic level (determined using compound-specific stable isotope analyses). We will further compare samples collected during the early and late Antarctic breeding season (e.g. November versus March) to investigate potential carry-over effects of the exposure in the inter-breeding season.

Additionally to the potential threat represented by the global contamination of the oceans, the Antarctic Peninsula has experienced an important warming over the last decades, attributed to the reduction of the sea ice cover on the western side and to a strengthening of the circumpolar westerlies on the eastern side, which likely results from anthropogenic activities (Vaughan et al., 2003). These perturbations are rapidly affecting the marine ecosystems in this region. For example, the decreased frequency of extensive winter sea-ice may be responsible for the reduced krill population sizes observed in the Antarctic Peninsula waters since the mid-1980s. The decline of this key species may profoundly affect the Southern Ocean food webs, by exerting a bottom up control on krill-dependent predators (Loeb et al., 1997, Atkinson et al., 2004). In the South Shetland Islands, Adelie and chinstrap penguin populations have been reduced by half during the last 30 years (Trivelpiece et al., 2011). Other krill eating species breeding in the Antarctic Peninsula are likely to undergo a comparable decline, such as storm-petrels. The Wilson's storm petrel (*Oceanites oceanicus*) is one of the most abundant seabird species in the world, and the smallest endotherm breeding in Antarctica during the austral summer (from November to March). This species feeds mainly upon krill (80-90 % of meals), and targets at a lower extent small fishes and amphipods (Quillfeldt et al., 2002). To the best of our knowledge, there is no fine scale tracking data of the movements at sea of the Wilson's storm petrel during the breeding season. The aim of our project was to investigate the foraging ecology of Wilson's storm petrels during the breeding season using GPS devices and to assess their breeding success.

Fieldwork

During the season ANT-Land 2019/20, fieldwork was carried out at the *Dallmann Laboratory*, *Carlini Base*, on King George Island from February to March 2020. Our fieldwork focused on two storm-petrel species: Wilson's storm petrel (*Oceanites oceanicus*) and Black-bellied storm petrel (*Fregetta tropica*).

Mistnet captures of adult storm petrels for contaminants and diet analyses

Adult storm petrels were captured with one mistnet (12 meters long, 3 meters high) in calm nights at the slope of the Tres Hermanos hill (Fig. 6.1.1 A,B), with previously established methods (Quillfeldt, 2002). Birds often regurgitate when flying into the net. Regurgitate samples were opportunistically collected in plastic microtubes. Blood, feather and preen oil samples were collected. Blood samples were collected on adults (0.05 ml) for mercury, diet and genetic analyses. Blood was taken from the brachial vein, by pricking the vein and taking a small drop with heparinized capillaries. Five body feathers per individual were collected for mercury and diet analyses. Preen oil was sampled from the uropygial gland of birds following a standardized protocol using pre-cleaned equipment and avoiding all contact with plastic (Hardesty et al., 2015). A small drop of preen oil was sampled after gentle massaging of the gland. In total 17 Wilson's storm petrels and 19 Black-bellied storm petrels were captured with the mistnet and sampled.

Fig.6.1.1: Nocturnal mistnet captures of storm petrels on the scree slopes of the Tres Hermanos hill (A), and adult Black-bellied storm petrel on hand (B).

Chicks monitoring

27 Wilson's storm petrel chicks were followed over the growth period (February to March), when they are left alone in the nest burrow during the day. During the first week after hatching, chicks were not manipulated to minimize disturbance during this period. Chicks were taken briefly (2-3 minutes), put on a digital scale for weight measurements and returned to the nest

(Fig. 6.1.2 A). Wing and tarsus length were also measured (Fig. 6.1.2 B). These protocols have been used during previous fieldwork campaign and were shown to have no measurable harmful effects on the growth and physiological condition of the chicks (Quillfeldt, 2001; Quillfeldt et al., 2009). Egg membranes were collected. Regurgitate and faeces samples were opportunistically collected when manipulating the chicks. Four chicks that died during the previous breeding season were found while monitoring the nests, and were sampled.

Fig. 6.1.2: Handling of a Wilson's storm petrel chick during monitoring (A), and measure of the wing length (B)

GPS tracking of adult Wilson's storm petrels

Following Hedd et al. (2018), we attached 6 GPS loggers (Pathtrack Ltd., Otley, UK; model nanoFix-GEO mini [1.0 g, 20x10x4.5 mm with a 5 cm antenna]) on adults captured in the nest burrow when returning to feed its chick. The tags were fixed to the four central tail feathers using Tesa tape and were removed after 2-7 days. Only one adult from each breeding pair was tagged in order to limit disturbance during the chick rearing period. Adults were tagged at the beginning of March, and we took care to select individuals whose chicks were well fed.

Marking of adults and chicks

Adults and chicks were marked with standard metal rings of the German Birds Ringing Scheme for identification.

Expected results

The level of mercury and plastic debris residues contamination is expected to increase with a more northerly breeding and inter-breeding distribution (lower contamination in Antarctic waters).

Since mercury biomagnifies within food webs, the level of mercury contamination is expected to increase with a higher trophic level.

The mercury and plastic debris residues contamination of petrel species is expected to be higher at the beginning of the breeding season for Antarctic species. Over the course of the season, the contamination level should drop as birds spend more time in Antarctic waters.

Adults are expected to show higher contamination in mercury and plastic debris residues than their chicks.

When comparing with petrel species breeding at other breeding sites, the contamination in mercury and plastic debris residues should be the highest in the North Pacific, intermediate in the Subantarctic and lowest in the Antarctic species.

Wilson's storm petrels are expected to forage in the vicinity of the breeding grounds during the chick rearing period, with foraging trips averaging 2-6 days.

Data management

All data collected during this project will be published in peer-reviewed international scientific journals. Data will further be made available in appropriate databases (e.g. PANGAEA data repository (World Data Center PANGAEA Data Publisher for Earth & Environmental Science (www.pangaea.de)).

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6.2 Biodiversity and adaptation of polar algae and their interactions with symbionts and parasites in a changing environment

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Jonas Zimmermann[2], Ulf Karsten[3] (not in field)
Hans-Peter Grossart[4,5], Alexandra Livenets[5]

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[3]Uni Rostock, [4]Uni Potsdam
[5]IGB

DFG priority program "Antarctic Research with Comparative Investigations in Arctic Ice Areas" SPP 1158 (DFG project numbers: WI 3765/2-1, ZI 1628/2-1, GR1540/33-1)

Outline and objectives

Antarctic marine biodiversity has been considered for a long time as species-poor constrained by a harsh environment. Mainly Antarctic microorganisms are still poorly explored, and hence the impacts of on-going global environmental change pose challenges to the present and future understanding of Antarctic biodiversity and related ecological functions. Our projects deal with biodiversity and adaptation processes of polar algae, divided into three subprojects (A) Adaptation of the green seaweed Ulva and its microbiome to cold temperature in Antarctica, (B) Ecological role of fungal parasites on benthic diatoms of polar coastal waters and (C) Biodiversity and biogeography of marine benthic diatoms in Antarctic and Arctic shallow water coastal zones. These projects focus on the following two main research questions:

(1) How do cross-kingdom interactions contribute cooperatively to the cold-stress adaptation of macroalgae? (**Project A**) The response of seaweeds to a changing environment must be studied in the context of its associated microbiome. The green macroalga *Ulva* (or *Monostroma*) reacts adequately to cold stress if its microbiome can also adapt to environmental changes to provide the necessary algal growth-promoting factors (Alsufyani et al., 2020). The project addresses the adaptation of *Ulva* to cold temperature (i) by intrinsic changes in the algal metabolism due to differential gene expression and metabolite production and (ii) by extrinsic changes due to the associated microbiome maintaining providing algal growth factors.

(2) How do parasitic interactions with diatoms shape the polar benthic habitats? (Projects B, C) Diatoms can be affected by parasites (e.g., chytrids). The project will focus on benthic diatoms collected from many marine hard- and soft-bottom regions in the Potter Cove. We plan to evaluate benthic diatom biodiversity in fine-grained taxonomic depth and infection rates through parasites using a combination of field, culture, and culture-independent methods for phenotypic and genotypic identification and parasite quantification.

Three subprojects (A, B, and C) include the following research goals:

Project A: "Adaptation of the green seaweed *Ulva* and its microbiome to cold temperature in Antarctica (COLDULVA)". The scientific aims of the project are:

- To demonstrate that bacteria isolated from Antarctica temperate *Ulva* can improve the growth and development of warm temperate Ulva species when *Ulva* is shifted to low temperature and *vice versa*.
- To define the *Ulva's* core stress-responsive genes and metabolites.
- To prove the ecological significance of the upregulated genes and biomarkers in the Antarctica temperate *Ulva*.

Project B: "Ecological role of fungal parasites on benthic diatoms of polar coastal waters". The scientific aims of the project are:

- To study the occurrence and diversity of parasitic fungi on benthic diatoms in Polar regions (Potter Cove in the Antarctic and Kongsfjorden in the Arctic) using molecular techniques.
- To study parasite-host interactions: evaluate infection rates, identify pairs of host-parasite, using a combination of field, culture, and culture-independent methods.
- To evaluate the effects of climate change by studying how temperature change influences host-parasite interactions.

Project C: "Biodiversity and biogeography of marine benthic diatoms in Antarctic and Arctic shallow water coastal zones to evaluate the degree of endemism using fine-grained taxonomy and eDNA metabarcoding".

The scientific aims of the project are:

- To precisely identify the almost unknown benthic diatom biodiversity in fine-grained taxonomic depth in communities sampled in Potter Cove (Antarctica) and Kongsfjorden (Arctic) using a combination of field, culture and culture-independent methods for phenotypic and genotypic identification.
- To establish a taxonomically validated reference library for Polar marine benthic diatoms with comprehensive information on habitat, morphology and DNA barcoding for unambiguous identification.
- To apply this new taxonomic reference library for marine benthic diatoms in environmental DNA (eDNA) metabarcoding to access the concealed biodiversity and assess the status of the taxonomic coverage of different diatom groups in Antarctica and the Arctic.
- To provide the hitherto most comprehensive biodiversity data set as a baseline and reference for reconstructing paleo-environments and future changes of Polar coastal regions (sea-level rise, coastal erosion).

Fieldwork

A team of five scientists participating in this project traveled from Buenos Aires (Argentina) via Rio Gallegos to the Chilean Station *Presidente Eduardo Frei Montalva* on King George Island with Hercules military planes provided by the Fuerza Aérea Argentina (FAA). From *Frei*, the transport to the AWI *Dallmann Laboratory* at the Argentinean *Carlini Station* in the Potter Cove run by the Instituto Antártico Argentino (IAA) was carried out with Zodiacs and an Argentinean research vessel. Travelling and fieldwork were conducted during the period from the 26th of January to 22 February.

The AWI *Dallmann Laboratory* at the Argentinean *Carlini Station*, King George Island, Antarctic Peninsula (62°14'S 58° 31'W), is located at Potter Cove, which combines zones of glacier fronts, rocky shores, and extensive soft bottom areas.

Sampling took place in several locations around *Dallmann Laborator*y at the Argentinian scientific base *Carlini* and the Antarctic Specially Protected Area (ASPA) 132 (Fig. 6.2.1). The sites included shallow water locations that were reached easily by walking. Sampling from locations down to 60 m depth within the Potter Cove was carried out with the support of Argentinian scientists and divers. The area provided diverse habitats intertidal platforms for the sampling of benthic diatoms, biofilms, green macroalgae, and water samples (Fig. 6.2.2-5).

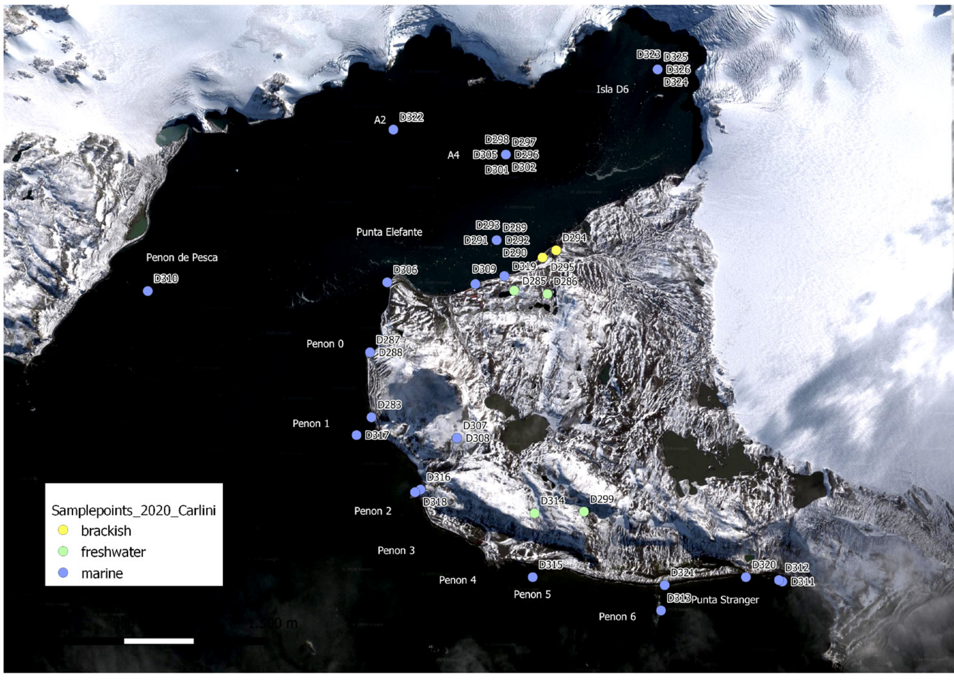

Fig. 6.2.1: Sampling sites in the Potter Cove area.

For project A, the ASPA 132 was entered by walking and approx. 50 specimens of the green algae such as *Ulva* spp. and *Monostroma* spp., and 15 water samples (ca. 5 l each, for water and microbiome analysis) were collected on the coastline at various sampling sites on low tides (please see the blue dots Fig. 6.2.1) (Quartino et al., 2005). The study aims to compare the core set of cold-responsive genes and metabolites between chambered and natural *Ulva / Monostroma* spp. in the Potter Cove. After identifying the right location, 3-5 individuals were collected at each sampling site. The specimens of up to five locations will be processed for further data analysis within COLDULVA. Each isolate was divided into three parts. The first part of the sample was be immediately ground in RNA*later reagent* (Qiagen, Germany) at the sampling site and transferred to the *Dallmann Laboratory*. The second part was quenched for metabolomics. The microbiome and phylogenetic analysis will be conducted with the third part of the alga. All samples were frozen at -80 °C in the laboratory and transferred to Bremerhaven (Germany). Water samples were taken (from tidal pools) for nutrient analysis, determination of morphogenetic activity, and metabolome analysis (Grueneberg et al., 2016; Alsufyani et al. ,2017; Kuhlisch et al., 2018).

For projects B and C, sediment surface samples were taken using Plexiglas sediment corer. It was manually pushed into the sediment (5 cm depth), and the upper 5 mm with the highest abundance of diatoms was removed with a spatula. At the same time, biofilm samples were taken, by scratching the surface of 5-10 stones with a knife. For project B, each sample was divided into three parts and prepared the following way: (i) to the part for DNA analysis ethanol was added up to 70 %, and the samples are kept at -20°C; (ii) the part for microscopy was fixed with Lugol´s solution; (iii) live samples are kept cold and dark for microscopy and cultivation.

For project C, all samples were divided into 4 portions and will be used for 1) morphological identification of the mixed diatom community, 2) for isolation of benthic diatom strains, 3) for a community analysis via eDNA Barcoding, and 4) for biomass estimation via pigment quantification. Portion 1 was fixed immediately with alcohol; portion 2 was kept cold and dark during transport to the Botanical Museum Berlin and the University of Rostock where unialgal cultures are currently established; portion 3 was frozen and kept frozen until analysis at the Botanical Museum Berlin. Portion 4 is also stored frozen, will be later extracted with organic solvents for photometric chlorophyll measurements.

Environmental data will be provided by the scientific staff of the *Carlini Station*. Data concerning salinity, sediment surface temperature, photosynthetically active radiation (PAR, 400–700 nm), dissolved oxygen, and pH will be provided. For the determination of macronutrient concentrations, samples of the overlaying water were filtered and stored frozen until further analyses. Soluble reactive phosphorus (SRP), ammonium, nitrite, and nitrate (together comprising dissolved inorganic nitrogen, DIN), and dissolved silica (DSi, as of silicic acid) will be analysed according to Grasshoff et al. (1999). The sediments of each sampling point will be further characterized for water content, loss on ignition (LOI), and element content (C, N, P) using standard methods such as an element analyser (Fa. Elementar, vario EL III). Total phosphorus and SRP are measured photometrically.

Preliminary (expected) results

Project A: "Adaptation of the green seaweed *Ulva* and its microbiome to cold temperature in Antarctica (COLDULVA)."

Green seaweeds, such as Ulvales, lose their typical morphology completely when grown under bacteria-free (axenic) conditions or in the absence of the appropriate microbiome (Spoerner et al., 2012; Wichard, 2015, 2016; Ghaderiardakani et al., 2017). As a result, plantlets proliferate in an undifferentiated and callus-like morphotype. Based on an analysis of Ulva species, these malformations could be partly or entirely rescued by complementing the culture medium with appropriate marine bacteria or partly purified morphogenetic compounds (Alsufyani et al., 2020).

Previous research and our preliminary data indicate that the seaweed *Ulva* can adapt to a cold climate (Wiencke and Dieck 1989; Wiencke 1990; Wiencke and Clayton 2009). Whereas cold-adapted species can grow at 18 °C, warm temperate species cannot be transferred easily to cold temperatures. Indeed, young germlings of *U. mutabilis* and their associated microbiome often do not grow under cold conditions. Our preliminary results indicated that the essential bacteria release lower amounts of the algal growth-promoting factors (= morphogens) under harsh conditions. We thus hypothesized that the core microbiome of the warm temperate *Ulva* species is not sufficient to sustain algal growth under the changing temperature and vice versa. However, the cosmopolitan distribution of, for example, *Ulva compressa* suggests that this species can live in Antarctic, cold, and warm temperate regions. Newly identified species on the Shetland Islands are usually also extensively distributed in temperate waters. Overall, the *Carlini Station* of King Georg Island was an ideal place to investigate the Antarctic temperate Ulva species in the Inner Zone and at the intertidal platform *Peñón Uno* further outside Potter Cove (Fig. 6.2.2).

As bacteria associated with the Antarctic temperate species can contribute to *Ulva´*s growth at both temperature 2°C and 18°C, they might be ideal for transforming the warm temperate *U. mutabilis* to a cold-adapted species. Surface-associated bacteria from cold temperate *Ulva* species will be streaked directly onto Marine Agar (MA). All plates were incubated at 2 °C for 14 days, after which, distinct colonies were picked and transferred with sterile toothpicks into 96-well cultivation plates containing 200 µL axenic cultures of the cold temperate *Ulva* and *U. mutabilis* to investigate their algal growth-promoting activity at 4°C and 18°C (Fig. 6.2.3) (Spoerner et. al. 2012; Grueneberg et al., 2016; Ghaderiardakani et al., 2017).

For evaluation of the morphogenetic effects of the water samples and the isolated bacteria, we distinguished between different growth activities previously described in the tripartite community of *U. mutabilis* (Grueneberg et al., 2016). Preliminary results demonstrated that certain isolated bacteria from Antarctica promote growth and improve the development of the Mediterranean *U. mutabilis*. Typical phenotypes during early germling development were observed upon inoculation with bacteria collected in the Potter Cove (Fig. 6.2.3):

- Morphotype I: In the absence of any morphogenetic compounds, calloid development is caused, and cell wall distortions such as bubble-like protrusions are formed.
- Morphotype II: Algal growth is promoted through cell divisions, but cell wall distortions are still visible (e.g., in the presence of *Roseovarius* sp. MS2 only).
- Morphotype III: Normal cell wall development is combined with the formation of a rhizoid (e.g., in the presence of *Maribacter* sp. MS6 only), but no blade is formed.
- Morphotype IV: Synergistic effects of both factors result in normal growth and morphogenesis towards an adult *Ulva*.

Further experiments with a temperature change are still pending. Also, we will identify genes and metabolites patterns and networks under cold stress conditions. Whereas the bioassay, metabolome and transcriptome data will be processed independently, we aim to develop a model describing the signaling pathways involved in the cold tolerance, including the signal perception of the low temperature via regulation, transduction until transcription of the gene and the physiological response. In the long-term run, unbiased integration of metabolomics and RNA-seq data using a genome-wide reaction pair network will be applied to overlay metabolites and transcript data independently from a priori pathway definitions. We will create a network based on KEGG reaction pairs and search for sub-networks containing metabolically connected enzymes with differentially significant concentrations at the transcription level.

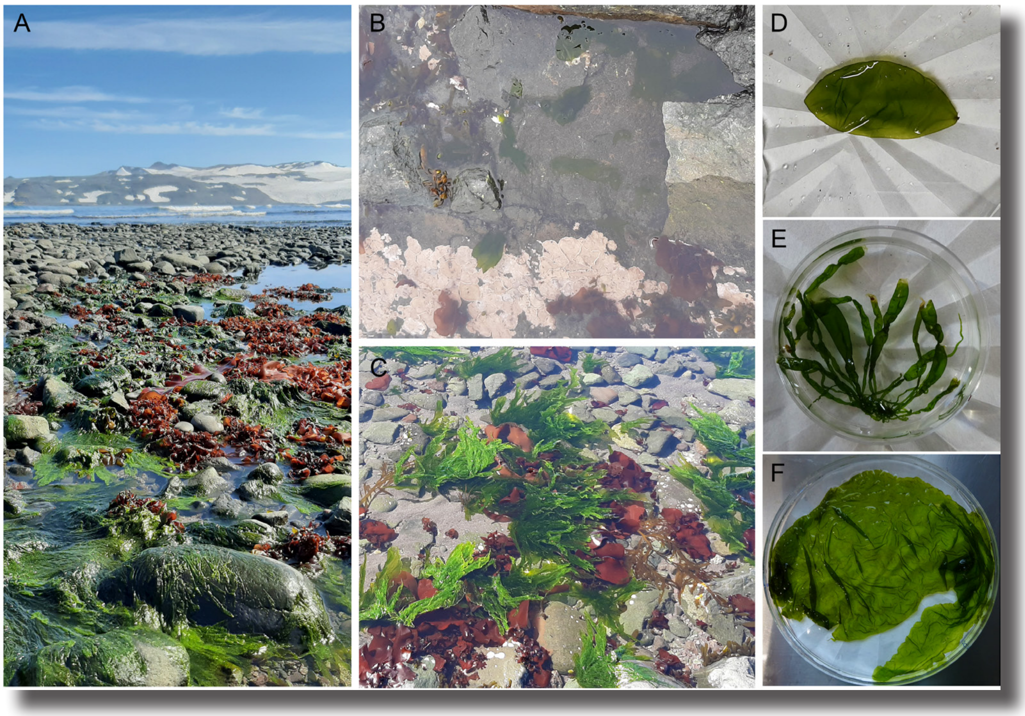

Fig. 6.2.2: Sample collection location. King George Island, Antarctica. (A, B, C) These figures illustrate the green algae samples predominantly distributed in intertidal zone. The beach has a range of green, red, and brown macroalgae (D, E, F) Green macroalgae collected during the expedition. Monostroma sp., Ulva sp., and Protomonostroma species were identified by morphological characteristics. Further molecular methods will be applied to confirm the taxonomic identification.

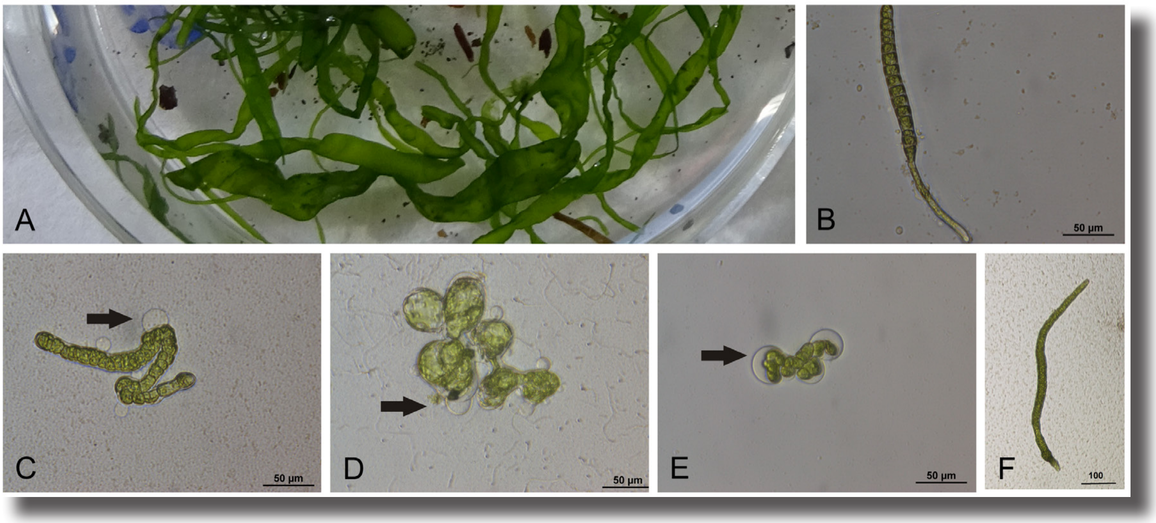

Fig. 6.2.3: Morphogenetic bioassays with Ulva spp. (A, B) An example of Ulva sp. collected from King George Island, and its plantlet has grown (complete morphotype) in the presence of the naturally associated bacteria. The bottom row illustrated germlings of Ulva mutabilis, which were grown with bacteria isolated from green macroalgae collected in the Potter Cove. (C, D) Germlings appeared with cell division but covered by protrusions, and differentiated rhizoid cells are missing in the absence of appropriate epiphytic bacteria cultivated at 18°C, (E) Ulva sp. plantlets reverted to an undifferentiated callus. (F) Characteristic usual morphotype with typical blade and rhizoid formation (complete morphotype) happened in the presence of appropriate epiphytic bacteria. Arrows indicate the typical colorless protrusions from the exterior cell walls.

Project B: “Ecological role of fungal parasites on benthic diatoms of polar coastal waters.“

Further analysis of diatoms included using a combination of culture and culture-independent methods. Live and Lugol´s-fixed samples will be microscopically screened for parasitic fungal infection. Microscopic observation of some samples already showed the presence of fungal infections in freshwater diatoms (Fig. 6.2.4). Staining with calcofluor white allows visualizing fungal structures attached to and inside of the diatom shells.

Fig. 6.2.4: Fluorescence microscopy images of freshwater samples. Fungal structures are visualized by fluorescent staining with calcofluor white (blue).

The ethanol-fixed and frozen samples will be used for molecular analysis of fungal infection. Molecular characterization of both host and fungi will allow discovering the hidden diversity of phytoplankton-fungal pairs, which may not be recognized based on morphological observations only.

For the molecular characterization of fungi newly developed primer set will be used to amplify and sequence the whole 18S RNA operon (Heeger et al., 2018; Wurzbacher et al., 2018). SMRT (single molecule real-time) sequencing technology will be used for long amplicon sequencing (Pacific Biosciences). Alternatively, Illumina Amplicon sequencing will be used to sequence ribosomal DNA regions: ITS (internal transcribed spacer) and LSU (large subunit). The Ribosomal Database Project and GenBank databases will be used for a taxonomic assignation.

For the molecular characterization of the phytoplankton host, the sequence of the commonly used barcoding regions of the chloroplast rbcL (rubisco) and nuclear gene (V4 subregion of 18S rRNA) will be done (Zimmermann et al., 2014b).

For the phylogenetic analysis, the obtained sequences will be compiled in a phylogenetic tree and examined for clustering patterns regarding sample location and environmental variables such as temperature. A set of closely related sequences will be collected from the GenBank, aligned with Clustal Omega, manually refined with BioEdit, and concatenated with MEGA7. The evolutionary history of the concatenated alignments will be inferred using both Maximum Likelihood and Bayesian methods, based on the General Time Reversible models, implemented in MEGA7 and MrBayes v. 3.1.2, respectively (Kumar et al., 2016).

The live samples will be used to establish cultures of infected and non-infected benthic diatom species according to established protocols (e.g., Stachura-Suchoples et al., 2016) and used to study different temperature effects. For that, the cultures will be comparatively exposed to different temperatures, and their growth performance recorded.

Project C: "Biodiversity and biogeography of marine benthic diatoms in Antarctic and Arctic shallow water coastal zones to evaluate the degree of endemism using fine-grained taxonomy and eDNA metabarcoding."

Benthic diatoms will be isolated in the laboratories of the BGBM Berlin and University of Rostock as soon as the samples arrive according to established protocols (Stachura-Suchoples et al., 2016). Conspicuous (larger) single cells can be picked using a Micromanipulator (Eppendorf) on an inverted microscope directly or from liquid enrichment cultures (Fig. 6.2.5).

All samples and isolated diatom cells from Antarctica will be maintained between 0 and 5°C and at 10–15 µmol photons m-2 s-1 provided by OSRAM Lumilux de Luxe Daylight under a 16-/8-h day/night cycle. The marine benthic diatom cultivation medium will always be prepared with sterile off-shore Baltic Sea water (salinity of 15 SA) salted up to a fully marine salinity of 34 SA (sel marin hw professional), enriched with Guillards f/2 nutrient solution (Guillard and Ryther, 1962) and sodium metasilicate solution.

In order to visualize the ornamented structures of the diatom valves as a morphological key character for identification, it is necessary to prepare their frustules. For this purpose, living diatom cells from unialgal cultures and environmental samples will be cleaned from all organic material.

Physical vouchers of each strain – slides, stubs, and unmounted frustules – will be deposited in and will be available through the Herbarium Berolinense (B); their DNA material in the Berlin-Dahlem DNA Bank Network.

Each prepared sample – mainly sediments and some rocks from Potter Cove - will be inspected for their benthic diatom composition (biodiversity) using light microscopy. Each taxon will be identified according to the available literature or knowledge acquired during this project. To record the occurrence and abundance of each diatom taxon at all sampling sites, at least 500 frustules in each sample will be counted, and the percentage of each taxon calculated.

For SEM visualization, either a Carl Zeiss DSM 960A (Carl Zeiss) operating at 10 kV and FE-SEM Merlin VP compact (Carl Zeiss, operated at 10 kV) for higher magnifications (University of Rostock) or FE-SEM Hitachi 810 (Freie Universität Berlin) will be used.

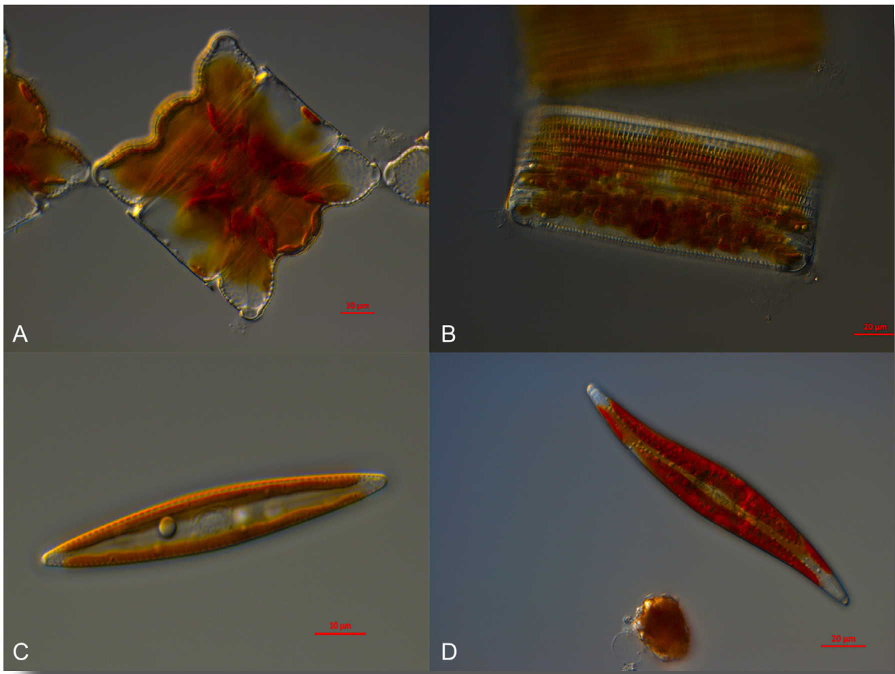

Fig. 6.2.5: Light microscopy images from a selection of diatom cultures isolated from environmental samples of the Potter Cove area. (A) Odontella, (B) Rhabdonema, (C) Navicula and (D) Pleurosigma.

The comparison of their occurrences in the different samples will set a baseline of diatom diversity under these conditions for future comparisons. Because benthic diatoms are also widely used as bio-indicators, the species composition gives hints on their ecological preferences or tolerances, and their frequencies reflect the prevailing environmental conditions, such as salinity, pollution, pH, or nutrients and hydrodynamic forces.

A subsample of each established unialgal culture will be harvested for DNA extraction by centrifugation. The DNA extraction will be executed with NucleoSpin Plant II Mini Kit (Macherey and Nagel) following the product instructions. The two barcode regions 18S V4 (SSU) following Zimmermann et al. (2011) and the *rbc*L locus following (Abarca et al., 2014) will be amplified via PCR. The PCR products will be sent for Sanger Sequencing to a commercial company (e.g., StarSEQ, Mainz). The sequences and their corresponding pherograms will be analysed and edited as well as aligned using PhyDE® and the implemented MUSCLE algorithm. Furthermore, they will be collated with the R-Syst::diatom database (Rimet et al., 2016; Vasselon et al., 2018) for an additional quality check.

Hence the synopsis of morphological and molecular data will not only provide a better and fine-grained taxonomy, which will help researchers to identify the respective species more easily morphologically, but it will also supply data for the molecular identification of a specific species. The different data will be combined, current species concepts will be revised and cryptic (no morphological differentiation possible), and pseudo-cryptic (morphological differentiation possible after high-resolution research) species will be described as new taxa for science (e.g., Stachura-Suchoples et al., 2016). All data provided by culturing, morphological and molecular analysis, e.g., names, pictures, morphometrical data, micro-morphological features, molecular data - are deposited combined in an online taxonomic reference library, providing researchers with a very effective tool to identify their taxa of interest. The reference sequences within this database, annotated to the information mentioned above, are a crucial requirement for the exact species assignment of the environmental sequence data gained via eDNA metabarcoding.

The eDNA from the environmental samples will be extracted with the NucleoSpin Soil Kit (Macherey and Nagel) following the manufacturer instructions, and the prePCR will be carried out following Visco et al. (2015) and Zimmermann (2014a) for 18SV4 and Vasselon et al. (2017) for *rbc*L. Illumia MiSeq sequencing (300 bp paired-end reads) will be conducted at and in close cooperation with the Berlin Center for Genomics in Biodiversity Research (BeGenDiv) of the Berlin Brandenburg Institute of Advanced Biodiversity Research (BBiB).

Bioinformatics analysis will be performed using MetBaN (Proft et al., 2017. For a refined species assignment the environmental sequences will be aligned with the reference sequences (INSDC, R-Syst::diatom and own reference library). The resulting alignment will be used for tree calculation with RaxMLHPC-MPI-SSe3. The trees will be visualized with the ETE toolkit, leading to phylogenetic based coalescent model approach (PCMA) (Zimmermann et al., 2014b) and trees for species assignment on a refined level. The resulting trees will be rendered, and the information will be converted into taxa spreadsheets.

These data could facilitate a quick and cost-efficient assessment of the given diversity in the compared ecosystems of interest, enabling the researchers to compare results from the eDNA metabarcoding with the classical species identification. The level of congruence or discrepancy between the taxa lists can lead to the level of concealed diversity or at least genetic variation in the diatom community. It allows quick feedback for potential “under description” and can lead to a review of the taxonomic implications using all the given information from the reference library to facilitate a refined taxonomic classification. A challenging step will be the cut-off/threshold resulting in species delimitation or description of the variety of haplotypes and/or ecotypes for specific species. This integrative dataset, together with HTS techniques, will help to monitor community changes, including the incursion (neobiata) and excursion of taxa, and to provide information on biodiversity patterns as well as dispersal mechanisms. Even genetic diversity and phenotypic plasticity within species can be addressed. These identification and monitoring tools provide the prerequisite for reconstructing paleo-environments as well as to detect future changes of Polar coastal regions due to, for example, coastal erosion driven by climate change and all its manifold consequences.

Data management

Results emanating from the investigations will be published in scientific journals and presented at local and international conferences. As requested by the involved universities (University of Rostock, the IGB and the Friedrich Schiller University Jena) all scientific raw data and laboratory records are stored as long-term archives for at least 10 years or even longer in the applicant’s working groups in always three parallel forms to ensure future reuse: (i) as hardcopy, (ii) on a hard disk and (iii) on compact disc. Also, all research data from this project will be submitted to the international the into the AWI PANGAEA data repository (World Data Center PANGAEA Data Publisher for Earth & Environmental Science (www.pangaea.de)), as well as to specific databases such as GenBank.

The permanently prepared diatom frustules plus fixed samples, as well as dried species of *Ulva* spp., will be deposited in the herbarium, and the DNA will be deposited in the DNA Bank at the Botanic Garden and Botanical Museum, Freie Universität Berlin. The obtained sequence data will contribute to global systematics projects (GBIF, EOL) and add hitherto missing data to databases (GenBank, MycoBank, AFTOL, RefSeq Targeted Loci (RTL)).

Data will be also submitted to the taxonomic reference library (e.g., strain numbers, taxon names, voucher codes, 18SV4 and rbcL sequences, pherograms, INSDC Accession Numbers, images, and morphometric data for each strain as well as the metabarcoding raw data) on the AlgaTerra Information System (Kusber & Jahn 2020), and interlinked with GBIF (Global Biodiversity Information Facility) and the Global Genome Biodiversity Network (GGBN, Droege et al., 2013). New species names and types will be published on the new registration system PhycoBank (DFG funding, JA-874/8-1) (Kusber et al., 2019), which is established and run by the FG Diatoms and housed at the Botanic Garden and Botanical Museum, Freie Universität of Berlin.

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7. FLIGHT CAMPAIGNS POLAR 6

No scientific flights campaigns were performed in season 2019/20.

8. OTHER SCIENTIFIC PROJECTS WITH AWI PARTICIPATION

8.1 Foraging ecology of Ross seals in the NORTHERN Weddell Sea

Marthán N. Bester[1], Nico Lübcker[1], Wiam Haddad[1], Horst Bornemann[2], Mia Wege[1,3] (not in field)

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[2]AWI
[3]Gateway Antarctica | UC

Objectives

During the *SA Agulhas II* Southern oCean seAsonaL Experiment (SCALE) Spring cruise (Oct – Nov 2019) a scientist of the Alfred Wegener Institute was part of a seal research team led by scientists of the Mammal Research Institute (MRI) at the University of Pretoria (UP). The spring cruise extends previous summer expeditions carried out by MRI-AWI-scientists along the east coast of the Weddell Sea, i.e. off Princess Martha Coast, Dronning Maud Land (*SA Agulhas II* SANAE 55 expedition 2016), and in the south-western Weddell Sea, i.e. Filchner Outflow System (*Polarstern* PS82 and PS111 expeditions 2013/14 and 2018). It was anticipated to instrument up to five Ross seals with satellite-linked position-temperature tags to investigate their ranging behaviour and, through the use of stable isotope analyses on sampled blood, fur and whiskers, and opportunistic scat and vomitus samples, their diet.

Ship-board census strips were aimed for post-hoc reconciliation of locations of seals spotted on ice with those identified on satellite images to improve abundance estimates.

Fieldwork

Two Ross seals, both adult females, were restrained and instrumented with SPOT satellite-linked dataloggers (Wildlife Computers). Location data were continuously provided by CLS Argos until February 2020, before the trackers were shed off during the Ross seal moulting season.

The distribution, density and percentage contribution of pack-ice seals during ship-board censuses in the marginal sea ice zone of the Lazarev Sea in Spring 2019 were investigated. Of the four pack-ice breeding phocid seal species, only three were sighted: adult crabeater seals (n = 19), leopard seals (n = 3) and Ross seals (n = 9) were sighted in the area bounded by 00°00' – 22°E and 56° – 60°S. Antarctic fur seals (n = 21) were only encountered on the outer fringes of the pack-ice, and Weddell seals were absent, presumably due to their primary use of fast-ice and inner pack-ice habitats close to the coast during October to November (breeding season). Five crabeater seal females and one leopard seal female attended pups. Of the Ross seals sighted, all were adults at the early stage of their breeding season.

Preliminary (expected) results

The two tracks will be pooled and analysed together with those (n = 11) generated during the 2015/16 summer relief voyage of the *SA Agulhas II* and the 2018 deployments on Ross seals (n = 2) off the *Polarstern* in the Eastern Weddell Sea.

On three occasions we were allowed to manipulate the ship's cruise track to include 10 nm long north-south survey lines, spaced 2.5 nm apart, during daylight hours. Firstly, this was done to cover the area in between longitudinally spaced, successive oceanographic stations as comprehensively as travel distance and speed allowed. Secondly, we aspired to an ideal survey design, which would have multiple regularly spaced transects extending in a north–south direction across the ice gradient. However, since we could not operate south of 60°S latitude, the SCALE Spring survey was of insufficient effort and scale, in both extent and duration, to locate Ross seals in particular during their austral spring breeding (pupping and mating) season in October/November.

Data management

Satellite linked SPOT tags (Wildlife Computers, Redmond, USA) transmit signals to the polar orbiting ARGOS satellites which relay received signals via the Centre de Localisations Satellites (CLS) in Toulouse, France, where the location data undergo a certain precision filtering algorithm before they are being harvested for further manufacturer-specific processing and cloud-based downloads via the Wildlife Computers data portal. The resulting primary data will be uploaded in PANGAEA following an established work-flow. The PANGAEA database contains a large set of circum-Antarctic oceanographic data relevant to the proposed project, and has already been extensively used for seal tracking data. All data and related meta-information will be made available in open access via the Data Publisher for Earth & Environmental Science PANGAEA (www.pangaea.de/) and will be attributed to a consistent project label denoted as "Marine Mammal Tracking" (MMT). In addition, all the data are archived on Movebank.org due to pre-installed linking of the CLS Argos account to the movebank project.

8.2 Beyond EPICA high resolition Radar survey at *Dome C*

Daniel Steinhage[1], David Lilien[2], Drew (R.) Taylor[3], Olaf Eisen[1] (not in field), Dorthe Dahl-Jensen[2] (not in field), Heinrich Miller[1] (not in field), J.-B. Yan[3] (not in field)

[1]AWI
[2]U CPH
[2]U AL

Objectives

By deploying a VHF radar especially designed for this expedition, the internal structure and ice thickness at Little *Dome C* was mapped in search for a location for a deep ice core drill site, aiming at the retrieval of an ice core up to 1.2 – 1.5 million years old. Based on other, earlier radio-echo sounding surveys as well as glaciological field work two neighboring areas of about 2 km in diameter and 3.5 km apart, roughly 34 km south-west of *Concordia Station* were identified as target area for the high-resolution radar survey.

Fieldwork

The high-resolution VHF radar survey at *Dome C* was conducted between 01 – 04 December 2019, out of a small field camp near the target areas. Acclimatization to the high altitude, set-up and technical checks of the radar were carried out at *Concordia Station*, after arrival on 21 November. A small camp was set-up by an ENEA/PNRA support team at *Little Dome C* (see Fig. 8.2.1) shortly before the data acquisition was started.

For direct comparison with other deployed radar systems, selected sections of earlier radio-echo sounding surveys were re-mapped, to allow direct evaluation of the improved data quality. The two defined target areas were covered by two sets of 10 and 9, respectively, 4 km long lines spaced 0.25 km apart. The survey was completed by recording a connecting profile between the target areas and all way back to *Concordia Station*. The map in Fig. 8.2.1 shows the acquired VHF profiles in the vicinity of *Dome C*.

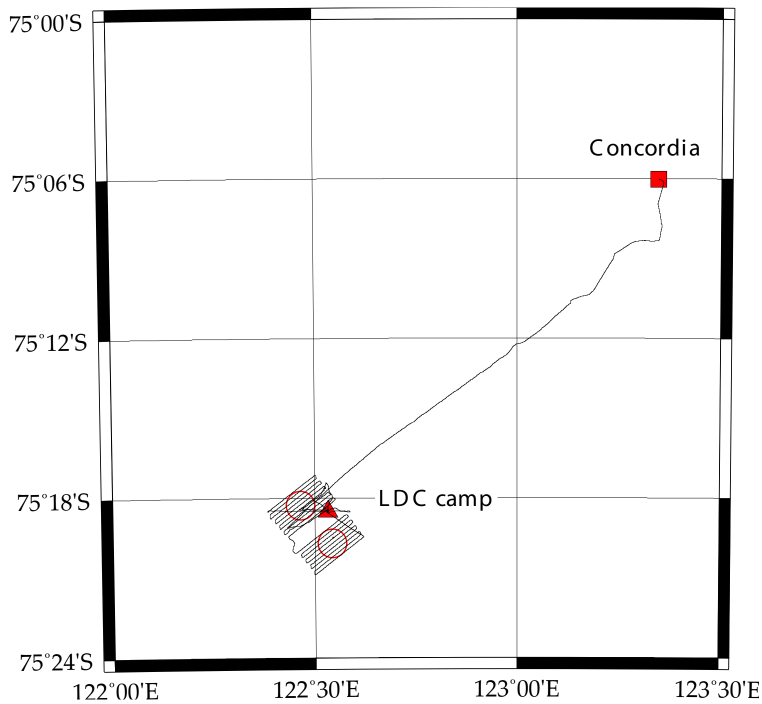

Fig. 8.2.1: Map showing the recorded VHF radar profiles

The deployed VHF radar system was a custom-made 8 channel system by the University of Alabama, operating in the frequency range of 170-230 MHz transmitting an 8 μs long chirp. For a detailed description of the system see Yan et al. (2020).

The radar acquisition system was installed in the back of a Pistenbully PB100 and travelling speed varied between 10 km/h (for the grid pattern) and 5 km/h for the profile returning to *Concordia Station*. The antennas were towed behind the Pistenbully.

Preliminary (expected) results

The high-resolution radar survey revealed the internal layering in the bottom part of the ice in very high resolution. The example in Fig. 8.2.2 shows a radar profile (single channel) along line 6 covering the southern target area. The presented data were processed in the field shortly after data acquisition and processing does not incorporate stacking of all recorded channels.

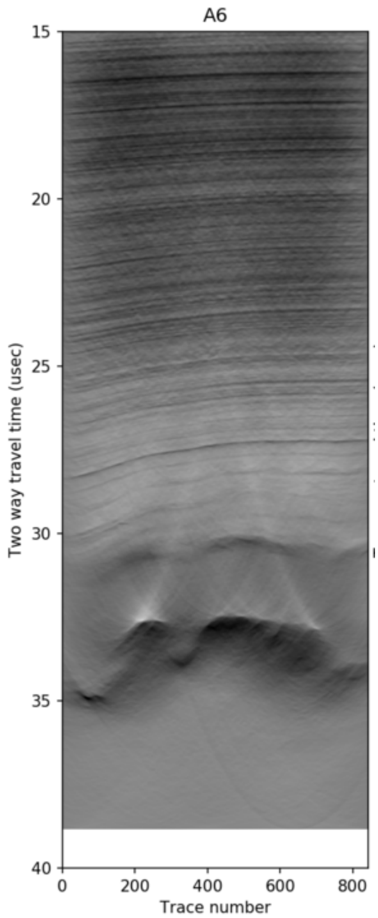

Fig. 8.2.2: Processed data sample along profile A6 (southern target area). The two-way travel time of 35 μs corresponds to an ice thickness of approximately 2,970 m. The reflections between 33-35 μs reveal the bed, the white spots above the bed are processing artefacts.

Data management

After full analysis the data will be made available in the World Data Center PANGAEA Data Publisher for Earth and Environmental Science (https://www.pangaea.de).

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Yan J-B, Li L, Nunn JA, Dahl-Jensen D, O'Neill C, Taylor RA, Simpson CD, Wattal S, Steinhage D, Gogineni P, Miller H, Eisen O (2020) Multiangle, frequency, and polarization measurements of ice sheets. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 13, 2070- 2080.

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ANNEX

A.1 Teilnehmende Institute / Participating Institutes

A.2 Expeditionsteilnehmer / Expedition Participants

A.3 Logistische Unterstützung, Überwinterer/ Logistics Support, Wintering Team

A.1 TEILNEHMENDE INSTITUTE / PARTICIPATING INSTITUTIONS

	Address
AWI	Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung Postfach 120161 27515 Bremerhaven Germany
BGBM, FU Berlin	Botanischer Garten und Botanisches Museum Freie Universität Berlin FG Diatomeen Königin-Luise-Str. 6-8 14195 Berlin Germany
BGR	Bundesanstalt für Geowissenschaften und Rohstoffe Stilleweg 2 30655 Hannover Germany
Charité	Charité – Universitätsmedizin Berlin Zentrum für Weltraummedizin und Extreme Umwelten Berlin CharitéCrossOver (CCO) Charitéplatz 1, Virchowweg 6 10117 Berlin Germany
CNRS	Institut Pluridisciplinaire Hubert Curien (IPHC) UMR 7178 CNRS-Unistra Département Ecologie, Physiologie et Ethologie (DEPE) 23, rue Becquerel 67087 Strasbourg Cedex 2 France
CSM	Centre Scientifique de Monaco Département de Biologie Polaire 8, quai Antoine 1er MC 98000 Monaco
CTBTO	Comprehensive Nuclear Test Ban Treaty Organization Vienna Austria
DLR	Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR) Institute of Space Systems Robert-Hooke-Str. 7 28359 Bremen Germany

	Address
EPHE	Ecole Pratique des Hautes Etudes Les patios Saint-Jacques 4-14 rue Ferrus 75014 Paris France
FAU	Friedrich-Alexander-Universität Erlangen-Nürnberg Lehrstuhl für Biophysik Henkestraße 91 91052 Erlangen Germany
FSU Jena	Friedrich-Schiller-Universität Jena Institut für Anorganische und Analytische Chemie Lessingstr. 8 07743 Jena Germany
Gateway Antarctica	Gateway Antarctica, School of Earth and Environment, College of Science University of Canterbury Forestrey Road, Ilam Christchurch, 8041 New Zealand
GFZ	Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences Potsdam Germany
HS Bremen	Hochschule Bremen Fakultät 4 Neustadtswall 30 28199 Bremen Germany
IAA	Instituto Antártico Argentino Departamento de Ciencias de la Vida Cerrito 1248 C1010AAZ, Buenos Aires Argentina
IGB	Leibniz-Institut für Gewässerökologie und Binnenfischerei (Abt. 3) Experimentelle Limnologie Alte Fischerhütte 2 OT Neuglobsow 16775 Stechlin Germany

	Address
JLU	Justus-Liebig-Universität Gießen Department of Animal Ecology & Systematics Heinrich-Buff-Ring 26 35392 Gießen Germany
KHU	School of Space Research Kyung-Hee University Gyeonggi Korea
KOPRI	Division of Polar Climate Sciences Korea Polar Research Institute Incheon Korea
LRU	La Rochelle Université Littoral Environnement et Sociétés (LIENSs), UMR 7266 CNRS - La Rochelle Université 2 rue Olympe de Gouges 17000 La Rochelle France
MPI	Max-Planck-Institute for Human Development Lentzeallee 94 14195 Berlin Germany
MRI | UP	Mammal Research Institute Department of Zoology and Entomology University of Pretoria Private Bag X20, Hatfield 0028 South Africa
NASA JSC	NASA Johson Space Center, Behavioral Health & Performance Laboratory 2101 NASA Parkway Houston, TX 77058 USA
NJIT	Center for Solar-Terrestrial Research New Jersey Institute of Technology New Jersey USA
NPI	Norsk Polarinstitutt Framsenteret Postboks 6606 Langnes 9296 Tromsø Norway

	Address
Penn	University of Pennsylvania, Perelman School of Medicine, Department of Psychiatry 423 Guardian Dr Philadelphia, PA 19004 USA
Pitt	University of Pittsburgh Department of Sports Medicine and Nutrition University of Pittsburgh 3860 South Water Street Pittsburgh, PA 15203 USA
ThINK	Thüringer Institut für Nachhaltigkeit und Klimaschutz Leutragraben 1 07743 Jena Germany
TROPOS	Leibniz-Institut für Troposphärenforschung e.V. (TROPOS) Permoserstraße 15 04318 Leipzig Germany
TU Dresden	Technische Universität Dresden Institut für Planetare Geodäsie Geodätische Erdsystemforschung 01062 Dresden Germany
TU München	Technische Universität München Boltzmannstr. 15 85748 Garching Germany
U AL	University of Alabama Tuscaloosa, AL 35487 USA
U CPH	University of Copenhagen Niels-Bohr-Institute Tagensvej 16 2200 København N, Denmark
UF	University of Florida, Fifield Hall 2550 Hull Road PO Box 110690 Gainesville, Florida 32611 USA

	Address
UNH	Space Science Center University of New Hampshire Durham, New Hampshire USA
Uni Potsdam	Universität Potsdam Institut für Biochemie und Biologie Karl-Liebknecht-Str. 24-25 14476 Potsdam OT Golm Germany
Uni Rostock	Universität Rostock Institut für Biowissenschaften Albert-Einstein-Straße 3 18059 Rostock Germany
University of Cologne	Institut für Geologie und Mineralogie Zülpicher Str. 49a 50674 Köln Germany
ULB	Université libre de Bruxelles – Faculté des Sciences Laboratoire de Glaciologie Department Geosciences, Environment, Society Av. F.D. Roosevelt 50, CP 160/03 B-1050 Brussels Belgium
WHOI	Woods Hole Oceanographic Institution 266 Woods Hole Rd. MS# 11 Woods Hole, MA 02543-1050 USA

A.2 EXPEDITIONSTEILNEHMER / EXPEDITION PARTICIPANTS

Name/ Last name	Vorname/First name	Institut/ Institute	Beruf/ Profession	Fachrichtung / Discipline
Bagheri-Dastgerdi	Saeid	AWI	PhD student	Climate Sciences
Bornemann	Horst	AWI	Scientist	Biology
Buchta	Eric	TU Dresden	Scientist	Geoscience
Eberlein	Lutz	TU Dresden	Engineer	Geoscience
Fromm	Tanja	AWI	Scientist	Geophysics
Ghaderiardakani	Fatemeh	FSU Jena	Scientist	Biology
Grasse	Torsten	BGR	Engineer	Electronics
Grossart	Hans-Peter	IGB, Uni Potsdam	Scientist	Biology
Henning	Silvia	TROPOS	Scientist	Meteorologist
Hoffmann	Mathias	BGR	Scientist	Geophysics
Kraemer	Philipp	JLU	Master Student	Biology
Lilien	David	U CPH	Scientist	Glaciology / Geophysics
Livenets	Alexandra	IGB, Uni Potsdam	PhD student	Biology
Loose	Bernd	AWI	Technician	Meteorology
Mustafa	Osama	ThINK	Scientist	Geography
Rümmler	Marie-Charlott	ThINK	Scientist	Biology
Steinhage	Daniel	AWI	Scientist	Glaciology / Geophysics
Taylor	Drew (Ryan)	U AL	Scientist	Electrical and Computer Engineering
Thébault	Justine	JLU, LRU	PhD student	Biology
Vallas	Benoit	CNRS, EPHE	Master student	Biology
Weller	Rolf	AWI	Scientist	Air Chemistry
Wichard	Thomas	FSU Jena	Scientist	Chemistry
Winterl	Alexander	FAU, WHOI	PhD student	Physics
Zabel	Paul	DLR	Scientist	Aerospace Engineering
Zeidler	Conrad	DLR	Scientist	Industrial Engineering
Zimmermann	Jonas	BGBM, FU Berlin	Scientist	Biology

A.3 LOGISTISCHE UNTERSTÜTZUNG, ÜBERWINTERER/ LOGISTICS SUPPORT, WINTERING TEAM

Name/ Last name	Vorname/First name	Institut/ Institute	Beruf/ Profession	Fachrichtung / Discipline
Ackle	Roman	AWI	Technician	Wintering Team 2020
Bähler	Stefanie	RFL	Technician	Logistics
Beyer	Mario	AWI	Technician	Wintering Team 2020
Brändli	Monika	RFL	Administration	Housekeeping
Brawand	Urs	RFL	Technician	Logistics
Briese	Wilfried	Siemens	Technician	Siemens Maintenance
Brodbeck	Boris	Buchele	Technician	Buchele Maintenance
Christian	Boris	RFL	Technician	Logistics
Czart	Thorsten	ZDF	Cameraman	Media
De Almeida Santos	Wanderson Divino	AWI	Cook	Wintering Team 2020
Denecke	Mirko	RFL	Technician	Logistics
Ebert	Matthias	ARD	Journalist	Media
Eder	Pitt	RFL	Technician	Logistics
Geiss	Peter	Pistenbully	Technician	Pistenbully Maintenance
Guba	Klaus	AWI	Physician	Wintering Team 2020
Heuck	Hinnerk	RFL	Technician	Logistics
Krams	Ralf	Pistenbully	Technician	Pistenbully Maintenance
Jörss	Anna-Marie	AWI	Scientist	Wintering Team 2020
Koch	Michael	AWI	Scientist	Wintering Team 2019
Korger	Edith	AWI	Scientist	Wintering Team 2019
Loftfield	Julia	AWI	Scientist	Wintering Team 2020
Matz	Thomas	AWI	Technician	Logistics
Mitteregger	Christian	RFL	Technician	Logistics
Mondini	Juan Pablo	ARD	Cameraman	Media
Oblender	Andreas	AWI	Technician	Wintering Team 2020
Panichi	Saverio	ENEA	Technician	Mechanics
Pennucci	Daniel	RFL	Technician	Logistics
Peters	Nils	AWI	Technician	Wintering Team 2019
Müller	Andreas	AWI	Scientist	Wintering Team 2019
Naundorf	Katharina	AWI	Cook	Wintering Team 2019
Riess	Felix	RFL	Technician	Logistics

Name/ Last name	Vorname/First name	Institut/ Institute	Beruf/ Profession	Fachrichtung / Discipline
Roetz	Oliver	ZDF	Cameraman	Media
Rotthäuser	Siegfried	IgH	Technician	Logistics
Scalet	Michele	ENEA	Technician	Mechanics
Schad	Thomas	AWI	Technician	Wintering Team 2019
Schubert	Holger	RFL	Technician	Logistics
Schumacher	Marcus	AWI	Scientist	Wintering Team 2019
Stakemann	Josefine	AWI	Scientist	Wintering Team 2019
Steckelberg	Birgit	AWI	Physician	Wintering Team 2019
Steffens	Dirk Peter Jörg	ZDF	Journalist	Media
Trumpik	Noah	AWI	Scientist	Wintering Team 2020
Vogel	Lutz	AWI	Technician	RFL
Wehner	Ina	AWI	Scientist	Wintering Team 2020
Wesche	Christine	AWI	Scientist	Logistics
Zink	Iris Else	ZDF	Journalist	Media

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