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Reports on Polar and Marine Research

Expeditions to Antarctica: ANT-Land 2018/19 Neumayer Station III, Kohnen Station, Flight Operations and Field Campaigns

Edited by

Tanja Fromm, Constance Oberdieck,
Tim Heitland, Peter Köhler

with contributions of the participants

HELMHOLTZ

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Titel: Die Kapazität der Neumayer-Station III wird während der Sommersaison durch Außenschlafplätze in den roten Biwak-Hütten erweitert (Foto: Edith Korger, Wien).

Cover: The capacity of Neumayer Station III is extended by red bivouac huts for more sleeping berth during summer season (Photo: Edith Korger, Wien).

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ANT-Land 2018/19

31 October 2018 - 1 March 2019

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

Field Operations Managers
Tim Heitland and Peter Köhler

Coordinator
Tanja Fromm

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*, der *Kohnen-Station* und im Zuge der *Polar 6* Flugkampagnen.

Während der Sommersaison ANT-Land 2018/19 sind 28 Projekte an den beiden Stationen, sowie die damit verbundenen Traversen mit Schleppzügen und mit der *Polar 6* 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 und zusätzlichen Gastprojekten. In den Kapiteln 4.1 bis 4.3 wird die jährliche Wartung der Observatorien beschrieben. In dieser Saison wurden die Observatorien für Luftchemie und Geophysik durch die beiden Projekte NPFAnt und DROMSEIS erweitert (Kapitel 4.17 und 4.10). In den Kapiteln 4.4 bis 4.14 geht es um Langzeit-Projekte aus unterschiedlichen Forschungszweigen, z.B. Meereis (AFIN), Tierwelt (PALAOA, SPOT, MARE, MARGEO) und medizinische Studien (Neuromayer). Nach dem ersten Jahr des Pflanzenanbaus wurde das Gewächshaus EDEN ISS erstmals umfassend gewartet (Kapitel 4.11).

Zwei unabhängige Projekte befassten sich mit den Strukturen unter dem Schelfeis und der nahe gelegenen Eiskuppel Halvfarryggen. Während des Projektes Sub-EIS-Obs wurde durch das Schelfeis gebohrt und geologische Proben vom Meeresboden genommen, während MT_ANT2 magneto-tellurische Sensoren verwendete, um die elektromagnetischen Eigenschaften der Erdkruste zu untersuchen (Kapitel 4.16 und 4.19).

Zwischen Weihnachten und Neujahr fanden während der Überfahrt von der *Kohnen Station* zur *Neumayer-Station III* drei wissenschaftliche Projekte zu geophysikalischen Eigenschaften des Untergrunds, zur Schneeakkumulation und Schneesturmvögeln statt (DROMSEIS, Kottasdichte und MUMIYO, Kapitel 4.10, 4.8 und 4.16).

Die Saison an der *Kohnen Station* war von glaziologischen Feldarbeiten in bis zu 100 km Entfernung geprägt. Schneeproben und flache Eiskerne wurden genommen, um die physikalischen Eigenschaften, die Akkumulation und die Isotopenzusammensetzung der oberen Schneeschichten zu analysieren (ASTI, KohnenQK-1 und SNOB, Kapitel 5.1, 5.4 und 5.5). Das EPICA-Bohrloch wurde zur Analyse der Eisdeformation neu vermessen und eine permanente Radarstation zur Messung der Firnverdichtung eingerichtet (EDML-Log und FIDEMEKO, Kapitel 5.2 und 5.3).

Die *Polar 6* startete am 3. November von den Falklandinseln für das geophysikalische Projekt AirLafonia (Kapitel 6.1), das paläogeografische plattentektonische Konfigurationen analysierte, die für paläo-ozeanografische und -klimatische Studien erforderlich sind. Nach dem Weiterflug in die Antarktis führte *Polar 6* Studien zu Plättcheneis und Eisströmen durch, um die Schmelzprozesse unter dem Schelfeis und die Dynamik des Eisschildes zu untersuchen (CAPIS, JuRas & Chirp, Kapitel 6.2 und 6.3). Beides wird für Prognosen des zukünftigen Meeresspiegelanstiegs dringend benötigt. Das wissenschaftliche Programm für *Polar 6* endete am 3. Januar 2019.

SUMMARY

The summer season in Antarctica is the short time between November and February, and the only time when the harsh climate allows access via plane and ship. During the austral summer there are enough days with warm and mild weather to permit major outside work (details in chapter 2 Weather conditions). But the time available 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 activities of the AWI and its partners at *Neumayer Station III*, *Kohnen Station* and during the *Polar 6* flight campaigns.

During the austral summer season ANT-Land 2018/19 we provided support to 28 different projects based at the two stations as well as during traverses in-between and using the *Polar 6*. 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 lengths and logistical requirements. Whenever possible, different scientific projects and logistical operations are combined to minimize environmental impact, and optimize 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 - either scientific and technical. The main logistical milestones and station operations are described in detail in chapter 3.

The season at *Neumayer Station III* is a synthesis of observatory maintenance, long running projects, winterers handover, station operations, visits and additional projects. Chapters 4.1 to 4.3 describe the yearly observatory maintenance. This season the airchemistry and geophysical observatories were accompanied by the two related projects NPFAnt and DROMSEIS (chapters 4.17 and 4.10). Chapters 4.4 to 4.14 are about long-term projects with

various objectives, e.g. sea ice (AFIN), marine life (PALAOA, SPOT, MARE, MARGEO) and medical issues (Neuromayer). After its first year of plant growing, greenhouse EDEN ISS with its space equivalent conditions had its first major maintenance (chapter 4.11).

Two independent projects focussed on the sub-ice structures beneath the ice shelf and the nearby ice rise Halvfarryggen. For Sub-EIS-Obs the ice shelf was drilled and geological samples taken from the seafloor, while MT_ANT2 used magneto-telluric sensors to recover electro-magnetic properties of the Earth crust (chapters 4.16 and 4.19).

Between Christmas and New Year a traverse from *Kohnen* to *Neumayer Station III* combined logistical needs with three scientific projects about geophysical properties, snow accumulation and snow petrel deposits (DROMSEIS, Kottasdichte and MUMIYO, chapters 4.10, 4.8 and 4.16).

The season at *Kohnen Station* was dominated by glaciological field work in the vicinity of the station and on a traverse up 100 km away. Snow samples and shallow ice cores were taken to analyse physical properties, accumulation and isotopic composition of the upper snow layers (ASTI, KohnenQK-1 and SNOB, chapters 5.1, 5.4 and 5.5). The EPICA borehole had been re-logged for monitoring ice deformation and a permanent radar station was set up to analyse firn densification (EDML-Log and FIDEMEKO, chapters 5.2 and 5.3).

The *Polar 6* started the season with the geophysical project AirLafonia (chapter 6.1) on 3rd November from the Falkland Islands analysing paleogeographic plate tectonic configurations required for paleo-oceanographic and -climate studies. After relocating to Antarctica, *Polar 6* carried out studies of ice platelets and ice streams targeting melt processes underneath the ice shelfs and dynamics of the interior ice sheet (CAPIS, JuRas &Chirp, chapters 6.2 and 6.3). Both are urgently needed for projections of future sea level rise. The scientific programme for *Polar 6* ended on 3rd January 2019.

2. WEATHER CONDITIONS DURING ANT-LAND 2018/19

Holger Schmithüsen AWI

The overall weather situation at *Neumayer Station III* during ANT-Land 2018/19 did not show significant deviations from the long-term mean. Concerning temperature, air pressure, wind speed, and the frequency of white-out, the monthly averages for the months November 2018 to February 2019 are all within two standard deviations of the long-term averages (Tab. 2.1).

The Temperature was close to the long-term mean during the entire season. Coldest temperatures were reached in November (Fig. 2.1), while December and January frequently show temperatures up to the freezing point. Air pressure in January was 7.2 hPa below the long-term mean, which corresponds to the slightly windier conditions than normal. February had less wind than normal, which is also reflected in the rather rare occurrence of white-out conditions: only 1 % of the 3 hourly observations reported white-out.

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

	Temperature	**Pressure**	**Wind speed**	**White-out**
November 2018	**-9.8°C** (-9.8 ± 1.5)°C	**979.9 hPa** (984.6 ± 4.2) hPa	**9.6 m/s** (9.4 ± 1.6) m/s	**26%** (18 ± 14)%
December 2018	**-4.8°C** (-4.8 ± 0.8)°C	**985.9 hPa** (987.5 ± 5.5) hPa	**7.7 m/s** (7.2 ± 1.4) m/s	**15%** (14± 11)%
January 2019	**-3.5°C** (-4.1 ± 1.0)°C	**982.2 hPa** (989.4 ± 4.0) hPa	**8.0 m/s** (6.6 ± 1.2) m/s	**10%** (10± 9)%
February 2019	**-8.3°C** (-8.0 ± 1.5)°C	**988.8 hPa** (987.1 ± 3.7) hPa	**5.1 m/s** (7.6 ± 1.5) m/s	**1%** (11±10)%

During ANT-Land 2018/19 there was only one event of significant and persistent snow accumulation (Fig. 2.1). During most of the season the snow level gradually decreased, which is due to sublimation and compaction of the snow/firn.

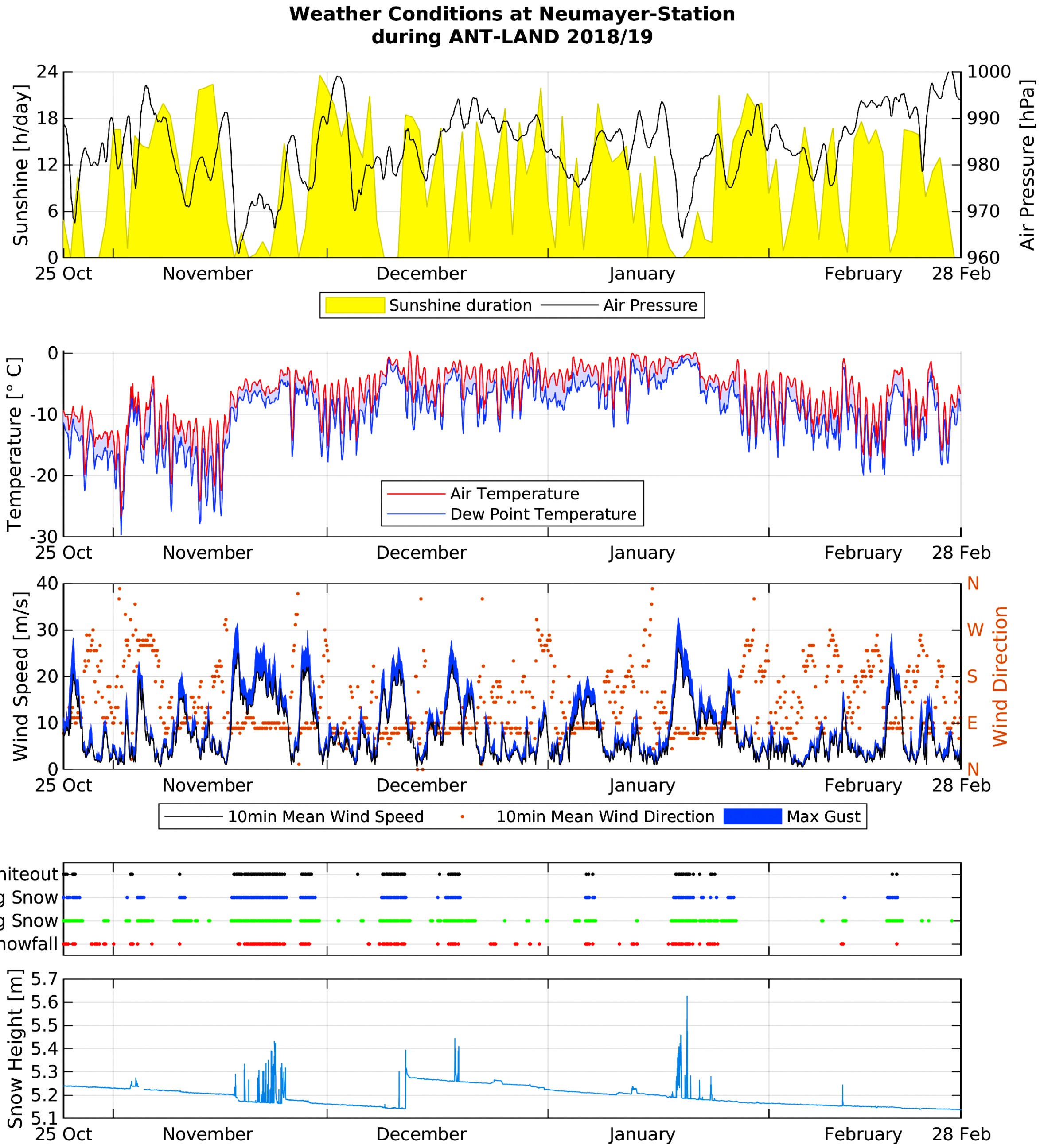

Fig.2.1: Weather conditions at Neumayer Station III during ANT-Land 2018/19

Data references

Schmithüsen, Holger; Müller, Hanno (2019): Meteorological synoptical observations from Neumayer StatWion (2018-10). Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Bremerhaven, PANGAEA, https://doi.org/10.1594/PANGAEA.900824

Schmithüsen, Holger; Müller, Hanno (2019): Meteorological synoptical observations from *Neumayer Station* (2018-11). Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Bremerhaven, PANGAEA, https://doi.org/10.1594/PANGAEA.900827

Schmithüsen, Holger; Müller, Hanno (2019): Meteorological synoptical observations from *Neumayer Station* (2018-12). Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Bremerhaven, PANGAEA, https://doi.org/10.1594/PANGAEA.900830

Schmithüsen, Holger; Müller, Hanno (2019): Meteorological synoptical observations from *Neumayer Station* (2019-01). Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Bremerhaven, PANGAEA, https://doi.org/10.1594/PANGAEA.900833

Schmithüsen, Holger; Müller, Hanno (2019): Basic and other measurements of radiation at *Neumayer Station* (2018-10). Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Bremerhaven, PANGAEA, https://doi.org/10.1594/PANGAEA.900823

Schmithüsen, Holger; Müller, Hanno (2019): Basic and other measurements of radiation at *Neumayer Station* (2018-11). Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Bremerhaven, PANGAEA, https://doi.org/10.1594/PANGAEA.900826

Schmithüsen, Holger; Müller, Hanno (2019): Basic and other measurements of radiation at *Neumayer Station* (2018-12). Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Bremerhaven, PANGAEA, https://doi.org/10.1594/PANGAEA.900829

Schmithüsen, Holger; Müller, Hanno (2019): Basic and other measurements of radiation at *Neumayer Station* (2019-01). Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Bremerhaven, PANGAEA, https://doi.org/10.1594/PANGAEA.900832

Schmithüsen, Holger; Müller, Hanno (2019): High resolved snow height measurements at *Neumayer Station*, Antarctica, 2018. Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Bremerhaven, PANGAEA, https://doi.org/10.1594/PANGAEA.900622

3. STATION OPERATIONS

Tim Heitland, Peter Köhler AWI

The AWI-Logistic's mission and focus is to provide a safe and functional environment to international scientists at *Neumayer Station III* to conduct their research. The time frame to access the remote location of Atka Bay is short due to the harsh climate and challenging infrastructure. Thus, the time available is limited and both scientific and logistic operations need to be thoroughly planned and coordinated. Our gateway to Antarctica and finally *Neumayer Station III* is Cape Town, South Africa. The intercontinental flights are scheduled to go to *Novolazarevskaya* air base that is featuring a solid ice landing strip, necessary for the heavy planes built for flying this distance and transporting the cargo needed. Connecting flights from *Novolazarevskaya* (feeder flights) distribute passengers and cargo to the stations throughout Dronning Maud Land. The whole operation is coordinated via DROMLAN (Dronning Maud Land Air Network), consisting of 11 nations operating in Dronning Maud Land with the flights organized by ALCI (Antarctic Logistics International, Cape Town).

Following intercontinental flight D02, the first feeder flight from *Novolazarevskaya* touched down at *Neumayer Station III* on 02.11.2018, officially opening the summer season 2018/19. The passengers were mainly technicians to start maintenance work and preparations for scientific endeavours and traverses.

Due to the annual snow accumulation *Neumayer Station III* regularly needs to be lifted twice per season with an interval between the procedures allowing the stations snow-fundament to settle down. The first lifting cycle started immediately and could be performed without any problems. Additional to the operations and science at *Neumayer Station III* it was also planned to open and run the Kohnen summer station, located approximately 800 km to the south of Atka Bay on the Antarctic plateau. In order to do so, personnel, scientific equipment, food, fuel and supplies needed to be transported to *Kohnen-Station* via a traverse. After preparation, the traverse left *Neumayer Station III* on 15.11.2018. The usual duration of the traverse is approximately 6 days. The onset of a prolonged period of bad weather with heavy storms, blowing-snow and major snow accumulation slowed the traverse down respectively put it on hold midway, allowing them to arrive at *Kohnen* after 16 days. The same weather made outdoor work at *Neumayer Station III* difficult or at times impossible during the second half of November.

From 16.11. to 28.11.2018 an inspection of the station took place by an AWI delegation, consisting of the heads of the legal-, human resources-, technical- and purchasing department. During the same period, *Neumayer Station III* hosted a film crew creating content for the television series "Galileo" and so contributing to AWI's outreach. The weather improved at the end of November allowing the scientific and technical field work to be completed on schedule.

In addition to the usual and ongoing terrain reconnaissance, a special effort to further explore a crack was made on 20.12.2018. The crack was discovered in the winter of 2017 within the ice shelf 8 km north-north-east of the station, origins from the shelf-ice edge in the east and runs to the west. Due to the proximity of the crack to the track leading towards the ships pier

"Nordostanleger" the track was closed for traffic. The further expansion of said crack is of utter importance for safe operations and prediction of the future condition of the shelf ice. GPS points have been taken.

An inspection of the South-African summer station that doubles as *Neumayer Station III*'s emergency base (E-Base) showed that the platform's southwestern running path broke due the heavy snow load, as well as one of the bracings of the antenna under the wind load. Other than that, the interior of the E-Base presented itself in working condition.

Due to logistical reasons, consisting mainly in weather restrictions that prevented flights with passengers for RV *Polarstern*, the landing of RV *Polarstern* at the shelf-ice-edge was postponed and the season planning was adjusted accordingly. The scientific and technical operations nevertheless continued on schedule and undisturbed, including the second cycle of the station's raising procedure.

At the end of December another reconnaissance mission of the above mentioned crack was performed. A newly delivered radar system (GPR (Ground penetrating Radar)) was used with one of our Arctic Truck cars. To do so, allowing us to track the crack to its westernmost extend about 100 meters east of the former track. GPS points were taken again to document the situation and its development.

On December 23 the 39th overwintering team arrived at *Neumayer Station III* (intercontinental flight D09) and the process of familiarization and working-in was started immediately.

On December 25 an intermediate traverse from the Kohnen station started back to *Neumayer Station III*, arriving there on 31.12.2018. On its way down two scientific projects (Kottaspegel and DROMSEIS) where performed. Arriving at *Neumayer Station III* the freight of Kohnen station was delivered in time to be loaded on RV *Polarstern*.

Starting in early January, the preparation of *Neumayer Station III*'s return freight and cargo operations with RV *Polarstern* and MV *Mary Arctica* took place. This included packing, stowing, logistics, paperwork and reconnaissance of the possible jetties. On 08.01.2019 followed by the extensive exploration of the northern jetty to prepare the *Polarstern* landing and unloading, GPS points and photographs were taken and shared with RV *Polarstern*.

Throughout the season, close contact was maintained with ALCI (Antarctic Logistics International, Cape Town) to ensure smooth, economical and timely flight operations. Due to extremely unstable weather, the planning of passenger and freight movements around the intercontinental flight D10 / D10a was particularly intensive.

The sea ice in Atka Bay was closed for access on 10.01.2019 as a recent satellite image showed fast-ice movements in the north-eastern part of the bay. Observations of a yearly recurring sea ice crack in the very south of Atka Bay showed an increasing width. Transition passes from the ice shelf to sea ice ware considered weaker and more dangerous for the formation of crevasses.

RV *Polarstern* reached the shelf ice edge at the northern pier on 13.01.2019. Cargo operations started the same day. The amount of cargo and fuel delivered, calls for an all machines and all hands operation, especially but not only for the stowage of fresh provisions at *Neumayer Station III*. In a collective effort the task was successfully and as planned finished on 15.01.2019

A trip of inspection by a delegation from science (Helmholtz Society, AWI, KIT(Karlsruhe Institute of Technology), DLR (German Aerospace Center), politics (BMBF, UBA) and media (ZEIT) to *Neumayer Station III* and RV *Polarstern* was scheduled, planned and prepared for the 12th to the 19th of January. Due to exceptionally bad weather conditions, the plans had to be adapted continuously. Finally limited flight conditions allowed the delegation only to visit *Neumayer Station III* on January 17th 2019. The 10-year anniversary of *Neumayer Station III* was celebrated the same day.

The operation of the station was handed over to the 39th overwintering team during a ceremony on 19th January 2019.

On 22nd January 2019 a 20-member delegation of the South African National Antarctic Program (SANAP) visited *Neumayer Station III* via helicopter.

Prevailing storms forced the supply vessel *Mary Arctica* to seek weather protection and postponed the planned landing from 17.01.2019 to 28.01.2019. Cargo operations were delayed and started on 28.01.2019, yet could be carried out as planned.

At the end of January, both the geophysics traverse and after closing of the *Kohnen Station* also her downhill traverse took place. On 06.02. an detailed technical inspection on the SANAP-Summerbase was performed, with the result of significant structural deficiencies.

From Feb. 2nd the DROMLAN weather forecast by DWD was broadcasted from Cape Town.

Summer season ended and the wintering officially started with the departure of the last summer guests on 27.02.2019.

3.1 Technical operations

Tim Heitland, Peter Köhler AWI

Scientific/technical outdoor facilities

During the entire season, snow clearing in the station area was routinely part of the task. The airfield was regularly prepared for the flight operations. Transportation to/from the winter storage also took place.

The technical-logistical support of the science teams included in this season the preparation and support of the traverse to the two geophysical observatories on the Halvfarryggen and Sörasen, as well as the rising procedure of the container platform of the EDEN-ISS. The balloon trench as a test structure to test the stability of the walls and ceilings formation was carried out in January. In view of the malfunctioning front snow blower it was determined that the ceiling formation did not develop optimally and was scheduled to be corrected in a following season. The access shaft to the Magnetic Observatory was raised by means of a wooden box around the height of the annual snow accumulation. Two ship discharge operations were carried out by technical team, as well as stowing freight containers for inbound and outbound cargo.

Station technique

- Wind turbine

After the wind turbine went out of operation in 2018, a modified set of aluminum wings with a carbon fiber reinforced plastic coating was installed following a natural vibration analysis. The blades now again 5 m long, have their original length and the associated income. They are balanced in weight outside the resonance range. The wind turbine was lifted by 2 m and successfully put into operation following this work.

- Cogeneration plant

To a great extent, he cogeneration plants ran trouble-free. The regular maintenance was carried out according to the engine running times. The engine of the CHP # 3 was replaced according to the maintenance cycle and brought to Germany for maintenance by ship. The isolation of an exhaust muffler in outdoor area D3, which was dissolved in the storm, was repaired.

- Air conditioning

The operation of the air conditioners showed no abnormalities. The work and maintenance to be performed consisted in the cleaning of the humidifier with change of the humidifier cassettes and bag filters. The UV tubes for disinfection were also changed. To repair storm damage, air ducts in the D3 area were replaced or repaired.

- Safety Technology

In the area of safety equipment, the control of the IT network and a review of fire detection system (fire dampers, smoke extraction system, testing the smoke detector from all detection loops) were carried out. The loudspeaker and light call system had been tested.

The semi-annual maintenance was carried out at the "FogTec" fire extinguishing system (high pressure fogging system). Together with the inspection of the RFL, the station and the technical facilities of the station were presented to the DNV / GL for inspection. No flaws were found.

- Wastewater plant and sanitary system

The routine maintenance and inspection work (regular withdrawal of excess sludge, control and rinsing of and cleaning of the grease trap) were performed.

- Station refueling, fuel tanks

During the season, the station tanks are filled with diesel fuel regularly. Gasoline tanks and the diesel filling station for the Pistenbullys are to be topped up. Depending on the air traffic, the tank container for refueling the aircraft was also regularly filled up. This includes the subsequent cleaning of the emptied tank containers and a regular inspection and cleaning of the fuel filter.

- Miscellaneous station technique

Regular work during the season included leveling the station and controlling the level system of the bipods. At the end of the hibernation, a hibernate pair was unscheduled raised and realigned by the wintering team. The alignment of the bipods from the vertical had reached warning levels. In April, the hydraulic side fender ring on deck zero on the west and south sides was realigned. The wood covering the ramp down to the vehicle hall was renewed using the same material.

Vehicle engineering

- Skidoos

In accordance with the intervals given by the manufacturer, maintenance was performed on all Skidoos. Repairs to the Skidoos related to repairs to the chassis and the correction of starter problems and power losses.

- Pistenbullys

To a large extent, work on the Pistenbully vehicles consisted of maintenance work following customer service intervals.

In addition, the following major repairs had to be carried out: replacement of track bars and hydraulic hoses, installation of charging devices. At Pistenbully 24, a high-pressure connection was installed for the operation of the Westa front-end snow blower. The work was carried out mainly by a Kässbohrer mechanic and the plant engineer of the station. The chassis of all PB 300 Polar were reviewed as part of a customer service campaign to avoid consequential damage. PB21 and PB30 were shipped to Germany for repair with *Mary Arctica*.

- Toyota HiLux - Arctic Truck

Arctic Truck performed regular maintenance on the 2 Toyota vehicles.

- Nansen sledges und Lehmann sledges

Various repairs, especially smaller wood and welding work were required on the Nansen sledges to keep them ready for use. Preventive maintenance work was carried out on the heavy-duty carriages in accordance with the manufacturer Lehmann.

Station maintenance work

The biggest work package, as every year at the beginning of the season, was the lifting operation of the station. From 06.11.2018 the first phase started and could be finished until 16.11.2018. Between both elevations, the EDEN ISS platform and the first measuring fields of the infrasound system I27DE were raised. The second lifting operation began on 30.11.2018 and was completed on 12.12.2018. The meteorology mast was lifted on 21.-22.12.2018, the Radio- Radom on 30.12.2018, the shortwave antenna on 31.12.2018 and the antenna masts of the radio beacon on 01.02.2019. The technical team was heavily involved in all ship discharge operations and performed the container stowage work.

The approach of *Polarstern* provided supply goods. Major maintenance work on the geophysics observatory included the construction of a riser element for the shaft. Finally, the manhole with the prefabricated element was raised. Also, the wooden roof of deck zero was renewed in the area of the ramp cover. The construction of the balloon trench was a major work package, which was jeopardized by the repair and upgrading of the PB 24 and a prolonged period of bad weather. Despite an incorrectly lowered ceiling formation, the construction principle could basically be made available for the Antarctic as well.

The bad weather phases were used for interior work. All essential maintenance work was successfully completed.

E-Base / SANAP-Summerbase

On 06.02.2019 a technical inspection of the SANAP-Summerbase took place. The overall-condition of the station is good and adequate for an emergency-Base.

The static situation of the station requires short-term action.

IT and communication

All maintenance and routine tasks documented in the GL shipmanager were successfully completed. After each storm, the antennas on the roof were visually inspected and general station operations supported.

IT

For the Department of Geophysics, a new Virtual Machine (VM) (antelope server) had been commissioned and integrated into the network. Another VM was set up for SPOT. In the long run, this will replace the currently installed hardware for data acquisition. Also, for the Expedition Interface System (EIS) a new VM with web server was provided. EIS was initially set up on the new VM and in Bremerhaven including synchronization and was released on 12.12 for live operation.

On 11.01 and 22.01 in the Neumayer air chemistry observatory (SPUSO) there was a failure of the fiber optic cable for several hours to the station. The reasons are on the one hand in high attenuation values of the line and on the other hand in a broken wire of the optical waveguide. The line to the SPUSO could be stabilized quickly again.

Communication

At the hospital, a speakerphone was set up. The room can now be reached with its own extension. As a result of storm damage repairs were necessary, which were successfully implemented by the radio technician to *Neumayer Station III.* An arm of the short-wave antenna of the SANAP-Summer Station had been torn up and renewed. On the roof of the *Neumayer Station III*, one of the four repeater antennas were torn from the bracket. The exchange took place within the planned renewal of all four antennas in late January / early February.

3.2 General flight operations

Tim Heitland, Peter Köhler AWI

Table 3.2.1 provides take-offs and touch-downs at *Neumayer Station III* and Atka Bay during ANT-Land 2018/19.

Table 3.2.1: Flight movements at *Neumayer Station III* and Atka Bay during ANT-Land 2018/19

Date	Time	Registration	Start	Destination
01.11.2018	2037	C-GEAI	Rothera	Neumayer
	2128	C-GEAI	Neumayer	Novo
02.11.2018	1810	C-GEAI	Novo	Neumayer
	1908	N131PR	Rothera	Neumayer
	1914	C-GEAI	Neumayer	Novo
05.11.2018	1143	C-GEAI	Novo	Neumayer
	1335	C-GEAI	Neumayer	Novo
07.11.2018	1259	C-GEAI	Novo	Neumayer
	1321	C-GEAI	Neumayer	Novo
08.11.2018	1624	N131PR	Neumayer	Novo
14.11.2018	2151	C-FKBX	Rothera	Neumayer
	2250	C-GEAI	Novo	Neumayer
15.11.2018	1145	C-FKBX	Neumayer	Novo
	1200	C-GEAI	Neumayer	Novo
16.11.2018	1757	C-GEAI	Novo	Neumayer
	1842	C-GEAI	Neumayer	Novo
	2002	C-GKKB	Rothera	Neumayer
	2040	C-GKKB	Neumayer	Novo
17.11.2018	1235	N131PR	Penguin Bukta	Atka Shelf
	1312	N131PR	Atka Shelf	Penguin Bukta
25.11.2018	1611	C-FKBX	Novo	Neumayer
	1626	C-GKKB	Novo	Atka Bay Sea Ice (NE of emp colony)
26.11.2018	0908	C-GKBX	Neumayer	Novo via Troll
	1154	N131PR	Whichaway	Atka Bay Skiway
	1558	N131PR	Atka Bay Skiway	Whichaway via FD
29.11.2018	1053	C-GKKB	Novo	Neumayer
	1126	C-GKKB	Neumayer	Halley
	1308	C-GKBX	Novo	Neumayer
	1422	C-GKBX	Neumayer	Novo
	1549	N131PR	Wolf's Fang	Atka Bay Skiway
	1737	N131PR	Atka Bay Skiway	Wolf's Fang via FD
30.11.2018	1154	N131PR	Whichaway	Atka Bay Skiway
	1532	N131PR	Atka Bay Skiway	Whichaway via FD
04.12.2018	2004	C-FKBX	Novo Runway	Neumayer
06.12.2018	1731	C-GKKB	Kohnen	Neumayer
06.12.2018	1739	C-GHGF	Halley	Neumayer
07.12.2018	0914	C-GKKB	Neumayer	Novo Runway
07.12.2018	0950	C-GHGF	Neumayer	Novo Runway
07.12.2018	1158	N-131PR	Whichaway Skiway	Atka Bay
07.12.2018	1555	N-131PR	Atka Bay	Penguin Bukta

Date	Time	Registration	Start	Destination
08.12.2018	0955	C-FKBX	Neumayer	Novo Runway
12.12.2018	1645	C-GHGF	Novo Runway	Neumayer
12.12.2018	1707	C-FKBX	Kohnen	Neumayer
13.12.2018	0825	C-FKBX	Neumayer	Utpostanen
13.12.2018	0921	C-GHGF	Neumayer	Neumayer
13.12.2018	1232	C-GHGF	Neumayer	Neumayer
13.12.2018	1839	C-GHGF	Neumayer	Neumayer
14.12.2018	0940	C-GHGF	Neumayer	Neumayer
14.12.2018	1120	N-131PR	Whichaway Skiway	Atka Bay
14.12.2018	1204	C-GHGF	Neumayer	Neumayer
14.12.2018	1549	N-131PR	Atka Bay	Penguin Bukta
14.12.2018	1606	C-GHGF	Neumayer	Neumayer
14.12.2018	1926	C-FKBX	Svea	Neumayer
17.12.2018	0951	C-FKBX	Neumayer	Kohnen
22.12.2018	1045	C-GKKB	Novo	Neumayer
23.12.2018	1231	C-GKKB	Neumayer	Kohnen
	1832	C-GKKB	Kohnen	Neumayer
25.12.2018	1306	N131PR	Wolf's Fang	Atka Bay Skiway
	1710	N131PR	Atka Bay Skiway	Penguin Bukta
28.12.2018	0902	C-GKKB	Neumayer	Kohnen
	1436	C-GKKB	Kohnen	Neumayer
	1528	C-GKKB	Neumayer	Novo
30.12.2018	1040	N131PR	Whichaway	Atka Bay Skiway
	1433	N131PR	Neumayer	Penguin Bukta
01.01.2019	1434	C-FTFX	Penguin Bukta	Atka Bay
	1556	C-FTFX	Atka Bay	Penguin Bukta
08.01.2019	1412	C-GHGF	Novo	Neumayer
09.01.2019	0953	HELI-1	Polarstern	Neumayer
	1040	HELI-1	Neumayer	Polarstern
	1153	N-131PR	Wolfs Fang	Atka Bay
	1217	HELI-1	Polarstern	Neumayer
	1256	HELI-1	Neumayer	Polarstern
	1433	N-131PR	Atka Bay	Penguin Bukta
10.01.2019	0855	C-GHGF	Neumayer	Kohnen
	1130	C-FTFX	Penguin Bukta	Atka Bay
	1259	C-GHGF	Kohnen	Neumayer
	1348	C-FTFX	Atka Bay	Penguin Bukta
11.01.2019	0953	C-GHGF	Neumayer	Novo
12.01.2019	1226	HELI-1	Polarstern	Neumayer
	1244	HELI-1	Neumayer	Polarstern
17.01.2019	0746	C-HGFX	Novo	Neumayer
	0743	C-GKKB	Novo	Neumayer
	0757	C-GEAI	Novo	Neumayer
	0903	C-GEAI	Neumayer	Novo

Date	Time	Registration	Start	Destination
	1005	HELI-1	Polarstern	Neumayer
	1036	HELI-2	Polarstern	Neumayer
	1048	HELI-1	Neumayer	Polarstern
	1115	HELI-2	Neumayer	Polarstern
	1123	HELI-1	Polarstern	Neumayer
	1143	HELI-2	Polarstern	Neumayer
	1147	HELI-1	Neumayer	Polarstern
	1319	C-GKKB	Neumayer	Novo
	1330	HELI-2	Polarstern	Neumayer
	1357	HELI-1	Polarstern	Neumayer
	1406	HELI-2	Neumayer	Forstefjell
	1445	HELI-1	Polarstern	Neumayer
	1459	HELI-1	Neumayer	Polarstern
	1733	HELI-2	Forstefjell	Neumayer
	1743	HELI-2	Neumayer	Polarstern
	2111	Polar-6	Neumayer	Novo
22.01.2019	1730	C-GEAI	Novo	Neumayer
	1739	C-GKKB	Novo	Neumayer
	1737	ZS-HND	SANAE	Neumayer
	1738	ZS-HNC	SANAE	Neumayer
	1741	Polar-6	Novo	Neumayer
	1933	HND	Neumayer	SANAE
	1933	HNC	Neumayer	SANAE
23.01.2019	0741	Polar-6	Neumayer	Halley
	0748	C-GEAI	Neumayer	SANAE
24.01.2019	1650	C-GEAI	Novo	Neumayer
25.01.2019	0830	N131PR	Whichaway Sky	Atka Bay
	0833	C-GKKB	Neumayer	Aboa
	1128	ZS-HND	SANAE	Neumayer
	1306	N131PR	Atka Bay	Penguin Butka
	1855	N131PR	Penguin Butka	Atka Bay
	2145	N131PR	Atka Bay	Penguin Butka
30.01.2019	1834	C-GKKB	Novo	Neumayer
	1941	C-GKKB	Neumayer	Novo
06.02.2019	1605	C-GEAI	Novo	Neumayer
07.02.2019	0904	C-GEAI	Neumayer	Novo
15.02.2019	0921	C-GKKG	Novo	Neumayer
	1128	C-GKKB	Neumayer	Novo
	1708	HND	SANAE	E-Base
	1751	HND	E-Base	Neumayer
	1923	HND	Neumayer	SANAE
21.02.2019	10:48	C-GKKB	Novo	Neumayer
	1154	C-GKKB	Neumayer	Novo
22.02.2019	1047	C-GKKB	Novo	Neumayer

Date	Time	Registration	Start	Destination
	1357	N131PR	Wolfs Fang	Neumayer
23.02.2019	0803	N131PR	Neumayer	Rothera
27.02.2019	0858	C-GKKB	Neumayer	Novo
	1558	C-GKKB	Novo	Neumayer
	1601	C-GEAI	Novo	Neumayer
28.02.2019	1013	C-GEAI	Neumayer	Rothera
	1017	C-GKKB	Neumayer	Rothera

During the season, information on flight weather was provided by the German Weather Service.

Between the 01.11.2018 and 05.12.2018 the service was located in Cape Town, whereby between the 01.12.2018 and 03.12.2018 the introduction of Christian Paulmann in the ongoing consulting tasks and in the weather events by Harald Rentsch was done. Christian Paulmann flew to *Neumayer Station III* on the 04.12.2018 and completely took over the consulting work until the 06.12.2018. The routine tasks included the ALCI briefing, DROMLAN routine consulting, intercontinental flights and intra-Arctic logistics and research flights, the ship and, if necessary, other meteorological advice (traverses, etc.). During the stay of the aviation weather consultant on the *Neumayer Station III*, there was also a regular weather briefing during the daily afternoon meetings.

On 06.02.2019, the weather briefing was taken over by Harald Rentsch in Cape Town, Aviation Office at ALCI. Due to a sufficient overlapping and training period, the routine tasks could be ensured over the whole time period.

3.3 Ship operations

Tim Heitland, Peter Köhler AWI

RV *Polarstern* was in the area between of 12.01. to 17.01.2019 The ship's unloading took place on 13.-15.01.19 without complications.

The prevailing storm situation after 17.01.2019 forced the MV *Mary Arctica* (MA) to seek weather protection and, by the then very dense sea ice belt in front of the piers, delayed the start of MA landing by 10 days. With the onset of southerly wind, the ice pressure on the ice shelf edge decreased, so that in the night of 28.01. to 29.01.2019 the cargo handling with the MA could be carried out.

4. NEUMAYER STATION

4.1 Long-term air chemistry observations at Neumayer

Rolf Weller[1], Helene Hoffmann[1], Marcus Schuhmacher[1], Ingeborg Levin[2] (not in field)

[1]AWI
[2]IUP Heidelberg

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 *Neumayer air chemistry observatory* 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 *Neumayer air chemistry observatory* 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 of the nine over-winterer, usually an air-chemist or meteorologist is responsible for the observatory.

Fieldwork

Concerning atmospheric chemistry, the project NPFAnt (Molecular steps of new particle formation at Antarctic coast) of the University of Helsinki and the Finish Meteorological Institute (FMI) was the scientific highlight of this summer campaign (ANT-Land 2018/19) at *Neumayer Station III*. This Finnish project was in cooperation with the AWI, chapter 4.17 describes the project details. Furthermore, the Long-Path Differential Optical Absorption Spectrometer (LP-DOAS) from the IUP Heidelberg (PI: Jan-Marcus Nasse and Udo Frieß), installed in austral summer 2015/16, was dismantled in December 2018. We tried to maximize the overlap of the LP-DOAS measurements with the contemporaneous Finnish field campaign. Unfortunately, this was impossible due to a serious irreparable damage of the instrument. The main objective of the LP-DOAS experiment was to measure bromine oxide (BrO) and iodine oxide (IO) within the atmospheric boundary layer, which would have been a valuable complement to the Finnish measuring program. Nevertheless, the LP-DOAS experiment was highly successful and provided invaluable results concerning reactive halogen chemistry at this site for more than 2 years, i.e. much longer than originally expected.

In addition, we successfully installed a new instrument to measure black carbon aerosol (Magee Scientific aethalometer type AE33 HS), and re-installed a repaired Aerosol Particle Sizer (TSI, APS 3321). Finally, the operation of the observatory was taken over by the new air chemistry over-winterer Marcus Schuhmacher.

Preliminary (expected) results

An in-depth evaluation and validation of the established long-term observations (LTO) was completed in May 2019. The outcome of this subsequent analysis revealed the high quality of the measured time series comprising

- condensation particle concentration (CPC)
- black carbon concentration (BC)
- aerosol scattering coefficients
- surface ozone concentration
- chemical (ionic) composition of the aerosol

with generally negligible data gaps, occasionally caused by short temporary instrumental problems or routine service operations. As an example, the measured surface ozone mixing ratios throughout the year 2018 is shown in Figure 1. The striking features are an O_3 maximum during winter with frequent concentration drops from August through October (so-called ozone depletion events caused by reactive bromine compounds).

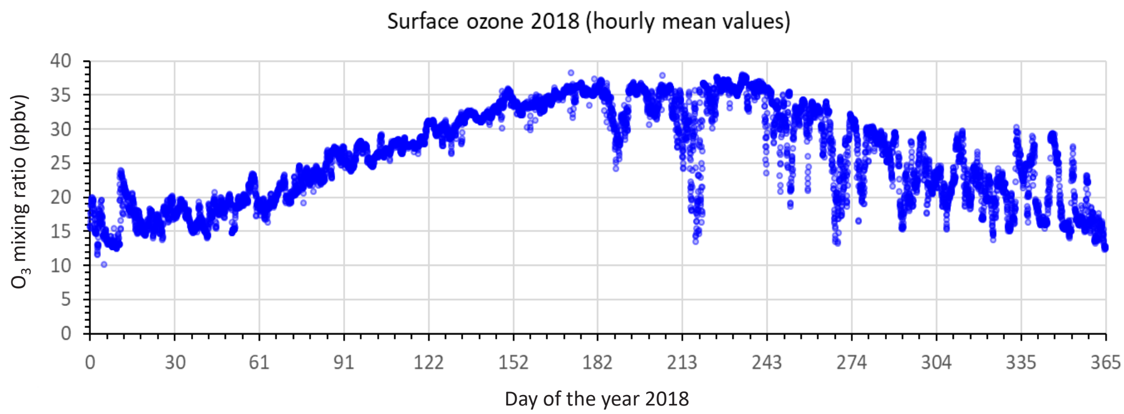

Fig. 4.1.1: Measured surface ozone time series (ppbv: parts per billion by volume) at Neumayer for the year 2018. Presented data are one-hour averages based on originally one-minute data.

Concerning the climate relevant black carbon aerosol, we could not verify any significant trend based on our now 20 year long continuous black carbon time series. Nevertheless, without much doubt anthropogenic combustion derived emissions will perpetually grow around and within continental Antarctica. Hence, there is a demand to continue BC observations with a view to document the impact of such activities on the Antarctic environment.

Finally, similar to the year 2016 we observed an extraordinary condensation particle peak in March 2018. Lasting for several hours, particle concentrations reached values far beyond the usual seasonal maxima around 2500 cm^{-3}. We never observed this peculiarity in our CPC time series covering now more than 25 years of continuous measurements. Up to now, there is no plausible explanation for this feature, though we are confident that neither contamination nor instrumental failure could have caused these events.

Data management

In the meanwhile, all results of the long-term observations at the *Neumayer air chemistry observatory* have been routinely archived after thorough evaluation in the respecting repositories:

- PANGAEA: https://doi.pangaea.de/10.1594/PANGAEA.902238
- GAW: http://ebas.nilu.no/default.aspx

4.2 The geophysical observatory

Tanja Fromm[1], Alfons Eckstaller[1] (not in field), Jölund Asseng[1] (not in field), Mirco Cerwonka[1], Katharina Ferstl[1], Matthias Hofmann[2] , Torsten Grasse[2]

[1]AWI
[2]BGR

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 kilometers. 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), c) GPS and d) monitoring infrasound for the common test ban treaty organisation (CTBTO; Pilger C, Ceranna L, & Bönnemann C, 2017).

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. 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., 2018).

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 Halfvar Ryggen and Søråsen, resp. Additionally to seismic broadband recording a small aperture detection array with 15 vertical seismometers placed on three concentric rings with a total diameter of almost 2 km completes station VNA2. Other unattended seismographic broadband stations record data at logistically feasible locations (see Fig. 4.2.1).

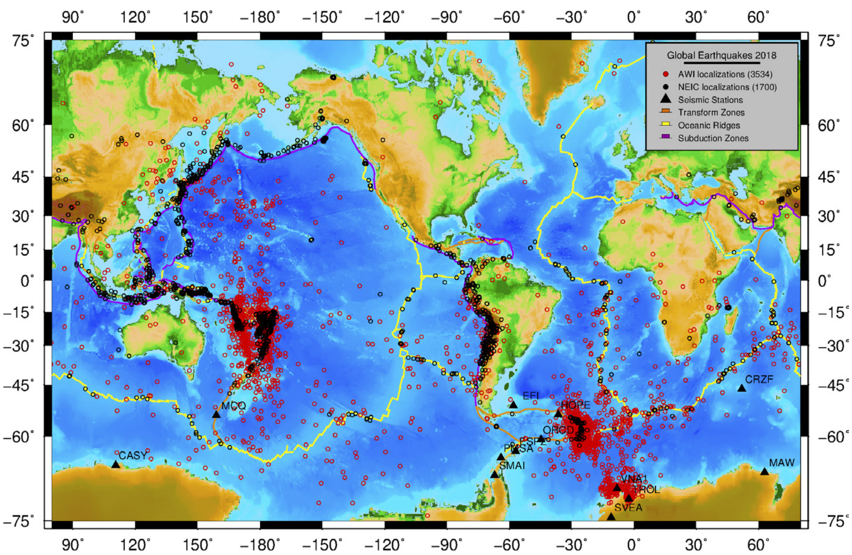

Fig. 4.2.1 Map showing seismic events recorded at the AW network in 2018

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. A simple all sky camera completes the instrumentation for geomagnetic research.

Since 2014 the observatory has been a certified member of the Intermagnet organisation guaranteeing quality and standard specifications for measuring, recording and exchanging data.

c) GPS recordings

We have recorded 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 atmosphere research and reveal characteristics of the Ekström Ice Shelf dynamics.

d) Infrasound

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 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 Station III*. It consists of nine elements 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 Station III*. IS27 went operational 2003.

Fieldwork

In this season 2018/2019, we serviced all seismometer stations of the AW network via land based traverses, by plane or helicopter. The service includes data download and a quick quality check. This season we changed the CMG-3ESP seismometer at the Swedish summer station SVEA with an MBB-2.

All instruments setup on the ice were dug out and rebuilt on the snow surface or the cover of the instrument pit was raised to surface level.

Preliminary (expected) results

a) The seismological network detected 28,049 arrivals and 5,985 events. 3,545 of those events are not yet included in global catalogs. (Fig. 4.2.1.)

b) The daily mean total magnetic field decreased by 60.9 nT from 38,241 nT to 38,180.1 nT (Fig. 4.2.2). This decrease consists of two parts: one part is the global weakening of the Earth's magnetic field, the other is the change of the remanent crustal magnetic field as the observatory moves with the ice shelf.

c) Ashtec GPS data show that *Neumayer Station III* moved 155 m from (8:16:44.75˚W,

70:40:06.19˚S) to (8:16:48.08˚W, 70:40:01.31˚S)

d) The infrasound array did not detect any suspicious event. No nuclear test is detectable for the year 2018.

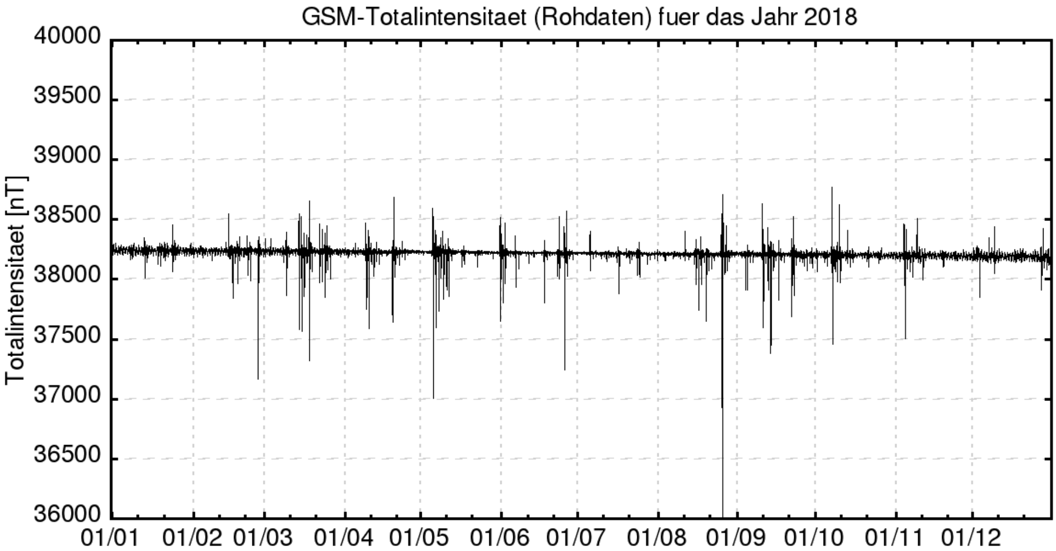

Fig. 4.2.2: Total intensity of the geomagnetic field recorded with the Overhauser GSM-19 at Neumayer Station III

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 (http://intermagnet.org/) and SuperMAG (http://supermag.jhuapl.edu)
- Unprocessed GPS data in Rinex format are available on request.
- Infrasound data can be obtained from BGR preferably via FDSN-Webservice (https://eida.bgr.de)

References

Eckstaller A, Müller C, Ceranna L & Hartmann G (2006) The Geophysics Observatory at *Neumayer Stations* (GvN and NM II) Antarctica. Polarforschung 76 (1-2), 3--24, https://doi.org/10.2312/polarforschung.76.1-2.3.

Fromm T, Eckstaller A & Asseng J (2018) The AWI Network Antarctica -- Alfred-Wegener Institute, Germany. Summary of the Bulletin of the International Seismological Centre, 22-36, 2309-236X, https://doi.org/10.5281/zenodo.1156983.

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.

Pilger C, Ceranna L & Bönnemann C (2017) Monitoring Compliance with the Comprehensive Nuclear-Test-Ban Treaty (CTBT). Contributions by the German National Data Center, Schweizerbart Science Publishers, Stuttgart, Germany.

4.3 Yearly maintenance of the Meteorological Observatory Neumayer

Holger Schmithüsen, Bernd Loose (not in field), Hanno Müller, Michael Koch — AWI

Objectives

The meteorological observatory *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). Furthermore, the station is to be certified as a member of the GCOS Reference Upper Air Network.

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 2018/19:

- 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

Furthermore, the following systems were newly installed:

- Automatic Weather Station (AWS) Halfvarryggen (this is a replacement of an AWS operated by the Institute for Marine and Atmospheric Research Utrecht)
- single column precipitation radar (Micro Rain Radar “MRR-Pro”, Fa. Metek, Germany)

From 2018-11-16 till 2019-02-15 the international coordinated project “Year Of Polar Prediction” (YOPP) conducted a so-called “Special Observing Period” (SOP). During the SOP the radiosoundings at *Neumayer Station III* were increased to 4 sondes per day.

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 for 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 2018/19.

Data management

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

4.4 AFIN – Antarctic Fast Ice Network

Hanno Müller, Stefanie Arndt (not in field) 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 programme 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 programme 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. 4.1.1). As in the previous years, 6 fixed sampling sites have been revisited monthly between annual formation and break up to obtain the mentioned measurements.

First sea ice, platelet ice and snow thickness measurements were carried out on 13 June 2018. Since entering the sea ice was not yet safe in the entire bay, only a first section of the route could be worked on. Afterwards, in total, 7 series of the entire transect could be conducted until entering sea ice was not safe anymore due to imminent break up. During austral summer, measurements have been carried out on 3 additionally parallel and perpendicular transects. Last measurements were performed on 30 December 2018. Table 4.4.1 summarizes all mentioned manual measurements.

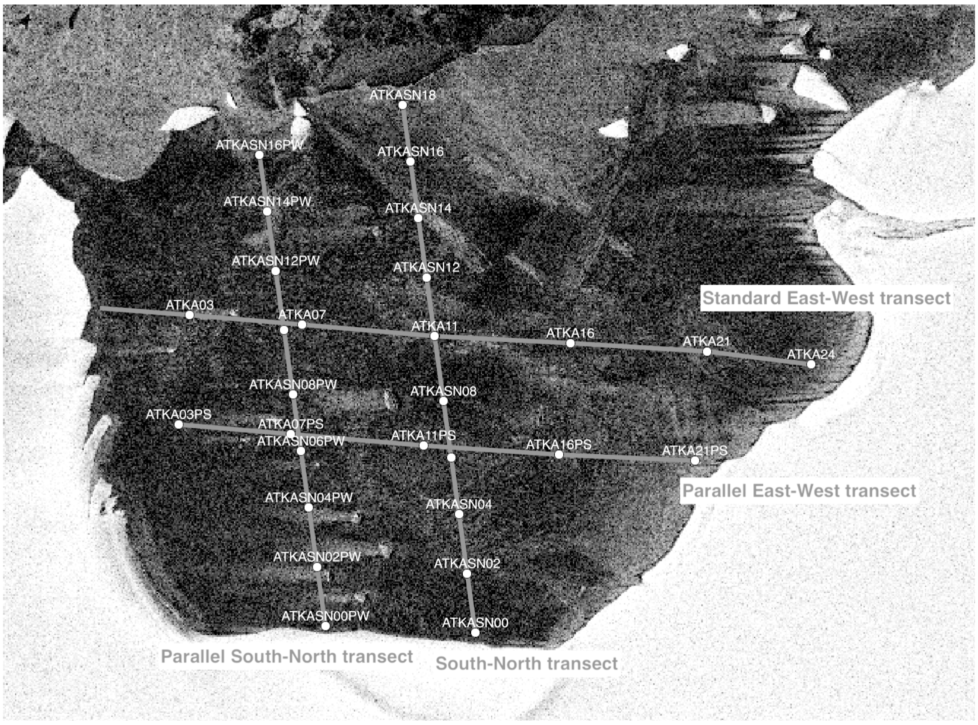

Fig. 4.4.1: Overview on fast ice conditions in Atka Bay in 2018. ATKA03-24 denote the routinely measurement sites of AFIN (standard E-W transect). During this season, additional parallel and perpendicular transects have been sampled. Numbers (e.g. 03-24) state the distance to the western (E-W transects) or southern (S-N transects) ice shelf edge in kilometers. The background of the map shows a Sentinel-1 SAR image recorded on 04 December 2018.

Tab. 4.4.1: Overview of all manual sea ice and snow thickness measurements. The transects correspond with the transect lines in Fig. 4.1.1.

Date	Standard E-W transect	Parallel E-W transect	S-N transect	Parallel S-N transect
13.06.2018	X			
21.07.2018	X			
16.08.2018	X			
19.09.2018	X			
11.10.2018	X (half)			
18.10.2018	X (half)			
16.11.2018	X			
25.11.2018			X	
02.12.2018		X		
03.12.2018				X
07.12.2018	X			
30.12.2018	X			

(2) Electromagnetic sea ice thickness measurements

In addition to the manual sea ice and snow thickness measurements, a ground-based electromagnetic induction device EM31-MK2 (Geonics Limited, Mississauga, Ontario, Canada) was operated measuring total sea ice thickness (sea ice thickness plus snow depth). Doing so, both test measurements as well as fixed transect measurements along the drilling transects (main Atka route, parallel and perpendicular) have been conducted (Fig 4.4.1). Furthermore, the EM31 device was deployed on the fast ice close the ice shelf edge for up to 24 hours in order to perform autonomous measurements. Table X.2 summarizes all mentioned electromagnetic measurements and its different purposes.

Tab. 4.4.2: Overview of all electromagnetic sea-ice thickness measurements (EM31). The transects correspond with the transect lines in Fig. 4.4.1.

Date	Testing	Standard E-W transect	Parallel E-W transect	S-N transect	Parallel S-N transect	Autonom.
20.06.2018	X					
10.07.2018	X					
11.08.2018	X					
17.10.2018	X					
28.10.2018	X					
15.11.2018	X					
25.11.2018	X					
29.11.2018		X				
30.11.2018						X
01.12.2018			X			
02.12.2018	X					
03.12.2018					X	
04.12.2018						X

(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). On the one hand, it was operated simultaneously to the EM31 transects in order to calculate the actual sea ice thickness as the difference of total sea ice thickness and snow depth. On the other hand, snow depth transects have been measured simultaneously to the manual drillings along the bore hole transect. Last but not least, the spatial distribution of snow depth has been investigated in the vicinity of four locked icebergs in Atka Bay. Table 4.4.3 summarizes all MagnaProbe measurements and its different purposes.

Tab. 4.4.3: Overview of all snow measurements with the MagnaProbe

Date	In addition to EM31 measurement	In addition to manual measurement	In the vicinity of the icebergs
26.11.2018			X
29.11.2018	X		
25.12.2018			X
26.12.2018			X
29.12.2018			X
30.12.2018		X	
02.01.2019			X
03.01.2019			X
08.01.2019			X

(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 at ATKA07 (see Fig. 4.4.1): One Ice Mass Balance buoy (IMB) deriving the sea ice growth (deployed on 09 June 2018) as well as one Snow Depth Buoy measuring the snow accumulation over the course of the year (deployed on 10 June 2018). Due to technical issues the temperature chain of the IMB needed to be replaced on 28 June 2018 in order to continue the measurements. Both buoys are still fully functional for now. It is expected that the buoys will drift with the sea ice into the Weddell Sea as soon as the fast ice in Atka Bay breaks up.

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 (28 October 2018) to avoid a complete coverage in the snow. Also, the battery finally run out of power on 21 November 2018. Therefore, a new battery was inserted to continue the measurements at the same place on 06 December 2018.

(5) Vertical water profiling below the fast ice

For testing purposes, a Conductivity-Temperature-Depth (CTD) sensor suit was lowered through a small crack in the fast ice on 08 January 2019. For the next season, this sensor set will be used regularly at ATKA03.

Preliminary results

(1) Manual measurements of sea ice and snow thickness

Fig. 4.4.2 summarizes all snow, sea ice and platelet ice thickness measurements as well as the observed freeboard over the season.

During the measuring period of half a year, snow accumulation across the bay of 35 (ATKA24) to 96 cm (ATKA03) was observed. Thermodynamic sea ice thickness growth was strongest at ATKA03 (2.11 m) and weakest in the middle of the bay at ATKA16 (1.53 m). In contrast, platelet ice accumulation was highest at ATKA07 (4.06m) and ATKA21 (4.12 m) and weakest at ATKA24 (2.06 m). The differences in platelet ice accumulation might be related to the locked ice bergs as well as the local topography of the bay (e.g. the ice rise).

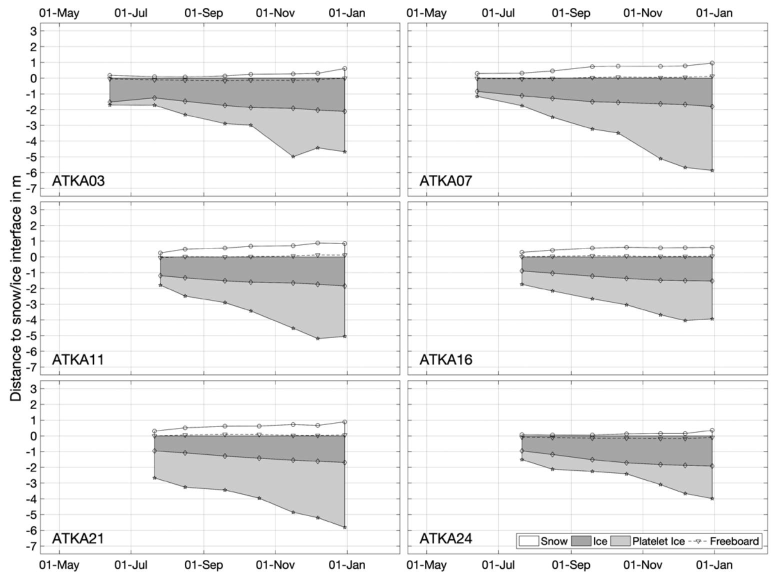

Fig. 4.4.2: Overview of all manual snow depth, sea ice and platelet ice thickness as well as freeboard measurements for the 6 ATKA points along the standard W-E transect (Fig. 4.4.1) in 2018

(2) Electromagnetic sea-ice thickness measurements

Fig. 4.4.3 shows an exemplary profile of the total ice thickness derived from electromagnetic induction measurements along the parallel south-to-north transect. Doing so, the EM31 was used in vertical and horizontal dipole mode, VDM and HDM, respectively. Qualitatively, the profile indicates one significant ridge at approx. kilometer 1.5, which is followed by again more flat ice. Between kilometer 6 and 9, the ice seems to be much more uneven with pronounced ridging events at kilometer 7.8 and 8.8. At kilometer 12, another ridge event is obvious followed by a slight decrease in sea ice thickness towards the sea ice edge. For the quantitative analysis, the final processing of the data is still missing.

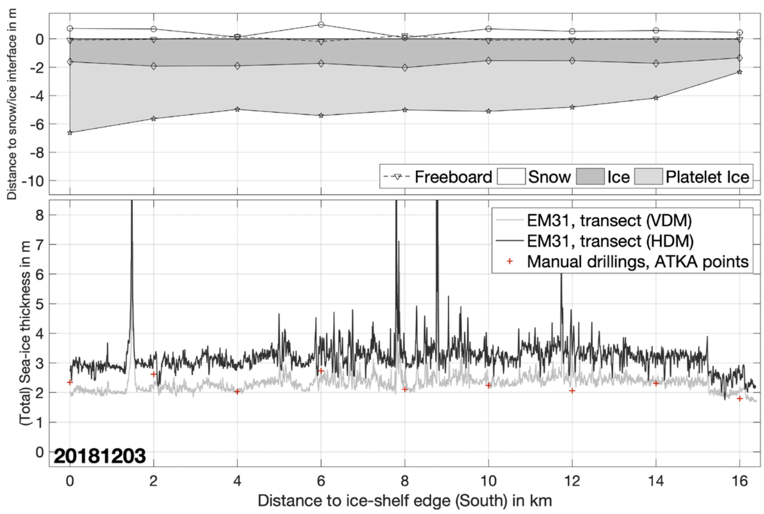

Fig. 4.4.3: (Upper panel) Manual sea ice and snow thickness measurements along the parallel S-N transect on 03 December 2018. (Lower panel) Total sea ice thickness measurements (sea ice thickness plus snow depth) derived from EM31 measurements. The EM31 device was used in vertical and horizontal dipole mode (VDM and HDM, respectively). Red crosses indicate the reference measurement from the manual drillings (sea ice thickness plus snow depth from the upper panel).

(3) Snow depth measurements with the MagnaProbe

Fig. 4.4.4 shows a composition of all snow depth measurements with the MagnaProbe in the vicinity of four icebergs in the southern part of Atka Bay. The measurements were conducted between 25 December 2018 and 08 January 2019 with a total profile length of around 30 km. Results indicate clearly thin snow layers in the lee of the icebergs persisting several hundred meters behind them. At the edge towards no-lee regimes, strong gradients towards snow depths of more than 1.20 m (limit of the MagnaProbe) were measured.

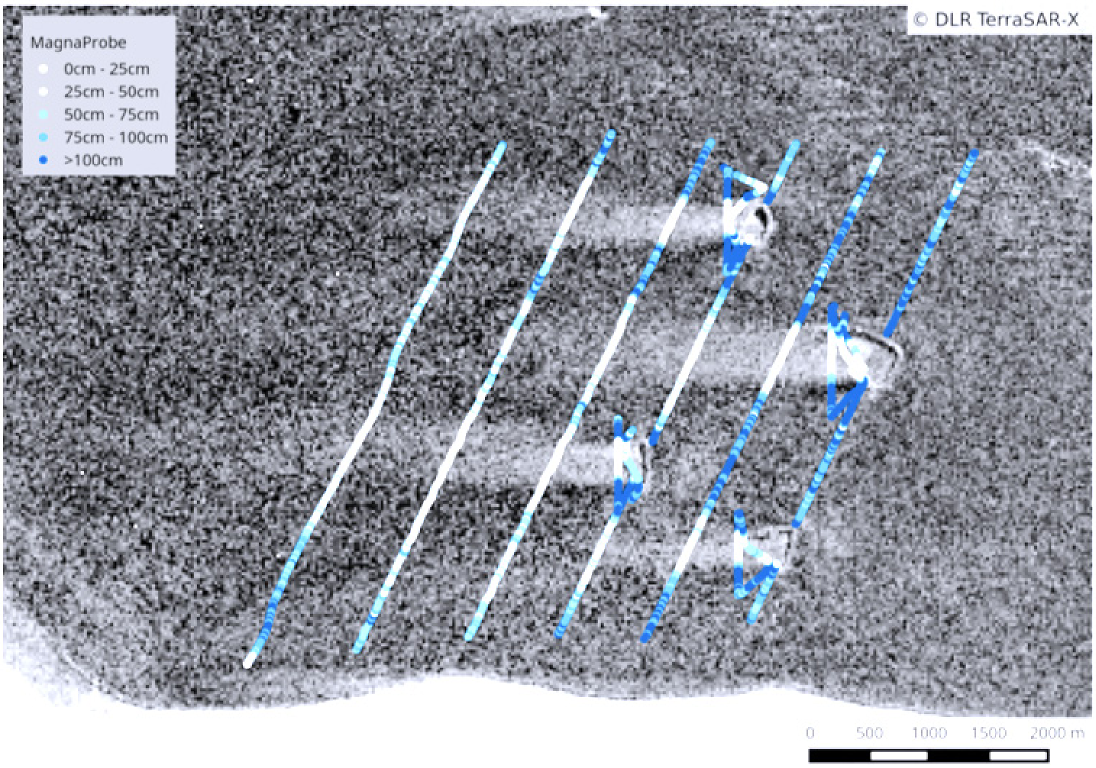

Fig. 4.4.4: Composition of all snow depth measurements with the MagnaProbe in the vicinity of the four icebergs. The background of the map shows a TerraSAR-X image (DLR) recorded on 10 December 2018.

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

Fig. 4.4.5 shows the snow accumulation of the deployed Snow Depth Buoy 2018S56 (at ATKA07) for the time period from 10 June 2018 to 10 February 2019. During this time period, 6 strong snow accumulation events can be identified which lead to a total snow accumulation of 60 to 70 cm. This corresponds well to the manual measurements at ATKA07. Further temporary events of significant snow depth increase and decrease are observed. They are, however, smoothed over time again. From mid-December to mid-January a slight but constant snowmelt of about 10 cm is observed, which is interrupted by a strong low-pressure system passing the area of Atka Bay.

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

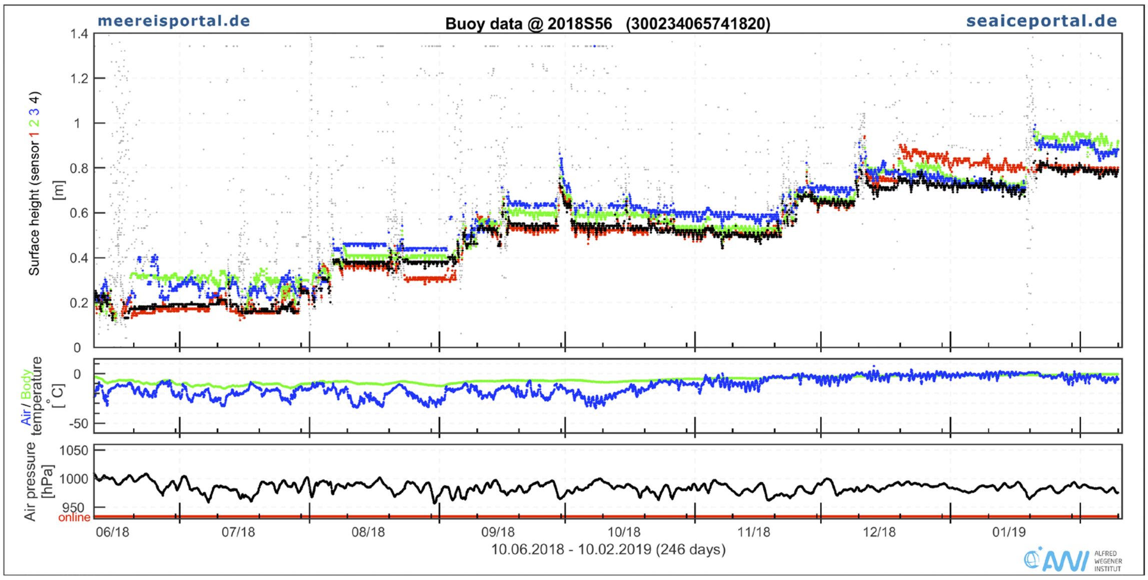

Fig. 4.4.5: Time series of snow accumulation along with respective meteorological conditions for Snow Buoy 2018S56, deployed on 10 June 2018 at ATKA07 (Fig. 4.4.1).

Data management

All manual drilling measurements are already post-processed and will be published in the 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 2018/19 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 repository.

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).

4.5 SPOT – Single Penguin Observation and Tracking

Daniel P. Zitterbart [1,2], S. Richter[1] (not in field), A. Winterl[1] (not in field), Céline Le Bohec[3], Aymeric Houstin[4], Ben Fabry[1]

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[3]CNRS/ CSM
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Outline

SPOT is a long-term remote-controlled observatory to monitor Emperor Penguins continuously throughout the year for ecological and behavioural 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 gain 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. 4.5.1) specifically designed to operate in Antarctic conditions is designed to continuously monitor the emperor penguin colony at Atka Bay to answer ecological as well as behavioral research questions.

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, and needs 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 with 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 cameras are equipped with a telephoto lens for either high-resolution images, stitched panoramic images, or video recordings of the colony (Fig. 4.5.2).

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 (Fig. 4.5.3, 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 2018/19 field campaign, SPOT underwent its annual maintenance cycle. This season the windows of both the high-resolution camera system as well the thermal imaging camera received new upgraded replacements. The high-resolution camera system window can be heated and we had repeatedly problems with delamination of the window heaters power coupling, that was replaced this year with a mechanical pressure based power coupling that has performed without fault since its installation. To improve low light imaging performance the IR filter of the high-resolution camera was removed. Furthermore, SPOT was moved approx. 200 m towards the South to account for the annual drift of the ice shelf (Fig. 4.5.4).

The data acquisition system was partially moved from a dedicated workstation to a virtual server based on the AWI operated computing center at *Neumayer Station III*. This reduces the hardware footprint in the computing center whilst increasing redundancy as snapshots of the operating system can be 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 can be produced in near real-time rather than the following year as conducted previously.

Preliminary (expected) results

We have been operating SPOT now for 6 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.

During ANT-Land 2018/19 we conducted the to date highest accuracy count of the Atka Bay emperor penguin colony to date using data collected in July 2018 when only breeding males are present. We estimate the population size to 12,933 – 14,024 breeding pairs (Fig. 4.5.5).

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. (Fig 4.5.6.)

Data management

All data recorded by SPOT is transferred annually to the AWI Data storage repository and stored in the long-term archive.

References

Dell AI, Bender JA, Branson K, Couzin ID, De Polavieja GG, Noldus LPJJ, Pé Rez-Escudero A, Perona P, Straw AD, Wikelski M & Brose U (2014) Automated image-based tracking and its application in ecology. Trends in Ecology & Evolution, 29(7), 417-428.

Gerum RC, Richter S, Fabry B & Zitterbart DP (2016) ClickPoints : an expandable toolbox for scientific image annotation and analysis (T Poisot, Ed.). Methods in Ecology and Evolution.

Gerum RC, Fabry B, Metzner C, Beaulieu M, Ancel A & Zitterbart DP (2013). The origin of traveling waves in an emperor penguin huddle. New Journal of Physics, 15, 125022.

Kucera TE & Barrett RH (1993). The trailmaster® camera system for detecting wildlife. Source: Wildlife Society Bulletin, 21, 505–508.

Lynch TP, Alderman R & Hobday AJ (2015) A high-resolution panorama camera system for monitoring colony-wide seabird nesting behaviour (H. Schielzeth, Ed.). Methods in Ecology and Evolution, 6, 491–499.

Newbery KB & Southwell C (2009) An automated camera system for remote monitoring in polar environments Cold Regions Science and Technology, 55, 47–51.

Richter S, Gerum R, Schneider W, Fabry B, Le Bohec C & Zitterbart DP (2018) A remote-controlled observatory for behavioural and ecological research: A case study on emperor penguins, Methods in Ecology and Evolution, 9(5), 1168-1178.

Zitterbart DP, Richter S, Spiekermann G, Behrens LK, Regnery J, Fontes RP, Hänssler T, König-Langlo G, Weller R & Fabry B (2014) Are environmental factors responsible for changed breeding behaviour in emperor penguins? Antarctic Science, 26(5), 563-564.

Zitterbart DP, Wienecke B, Butler JP & Fabry B (2011). Coordinated movements prevent jamming in an emperor penguin huddle (M. Perc, Ed.). PLoS ONE, 6, e20260.

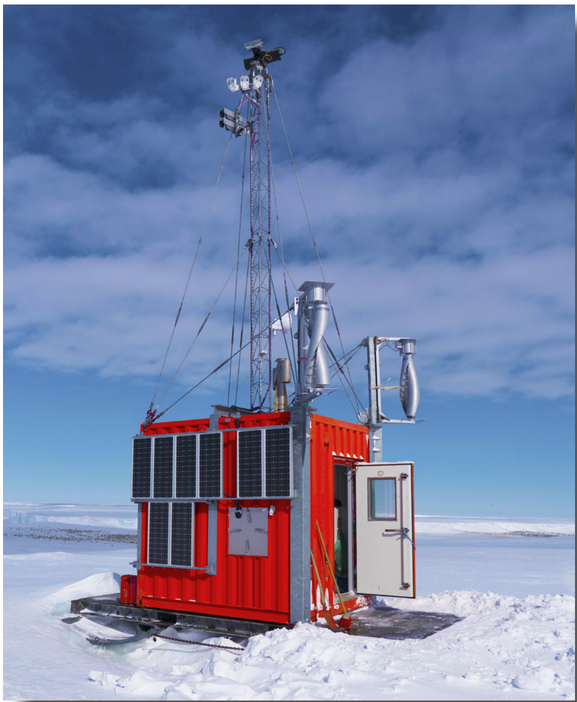

Fig 4.5.1: Detailed picture of the SPOT Observatory recorded in November 2018

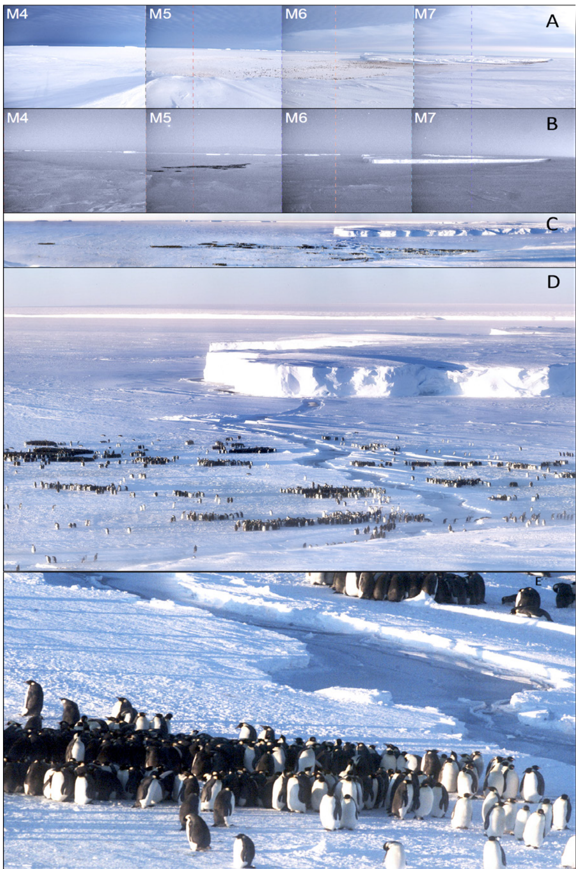

Fig. 4.5.2: SPOT Imaging capabilities. Overview cameras on top for day (A) and night (B) imaging. Panoramic (C) as well as full field of view (D) and full resolution (E) images of the high-resolution camera.

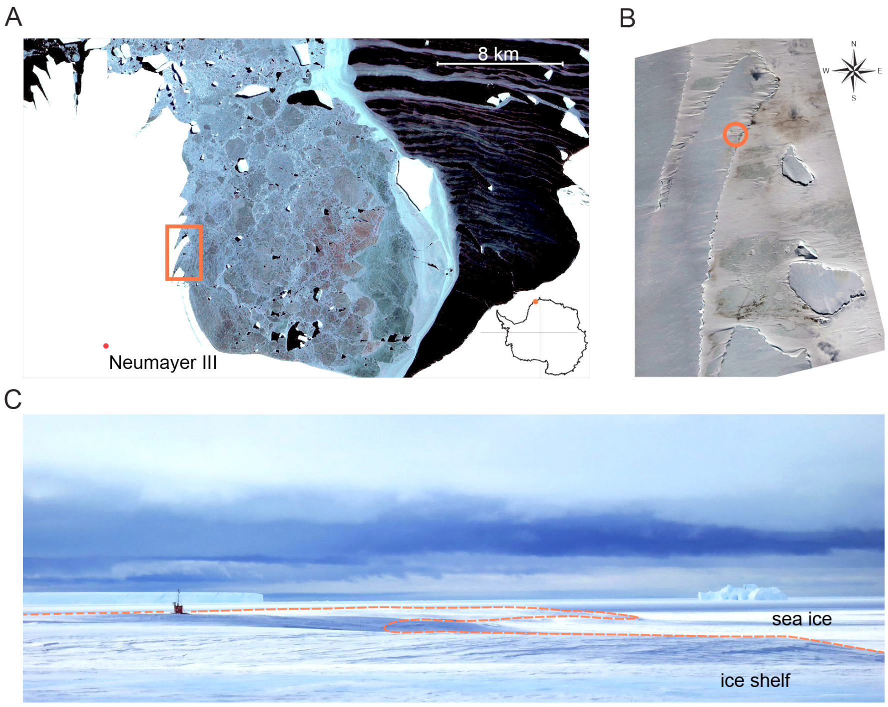

Fig. 4.5.3: Location of the SPOT observatory

A) Satellite image of Atka Bay (contains modified Copernicus Sentinel data (2017)). B) Detailed image of the area (2013). The location of SPOT is indicated by the orange circle; past positions of the penguin colony can be estimated from bird droppings on the sea ice (brown staining). C) SPOT is positioned close to the edge of the shelf ice (orange dashed line), providing an elevated viewing position over the bay area

Fig. 4.5.4: Location of the SPOT Observatory in respect to the emperor penguin colony in November 2018.

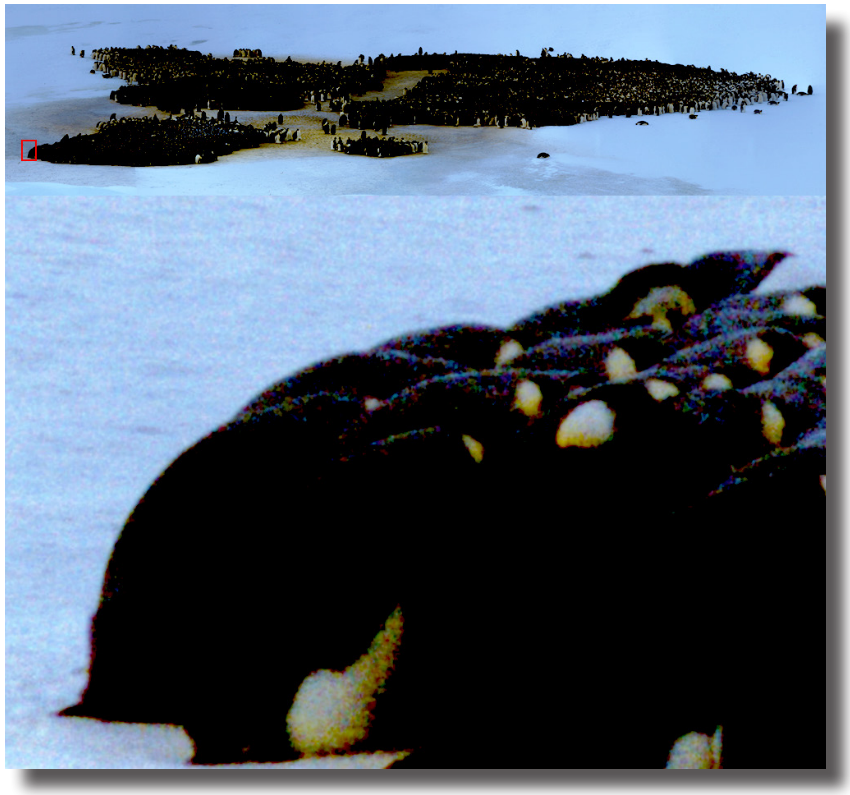

Fig. 4.5.5: Top: High resolution panoramic images of the whole Atka Bay colony created on July 9th 2018 which was used for abundance estimation. Bottom: Inset showing the full resolution of the images (corresponds to red square in top image).

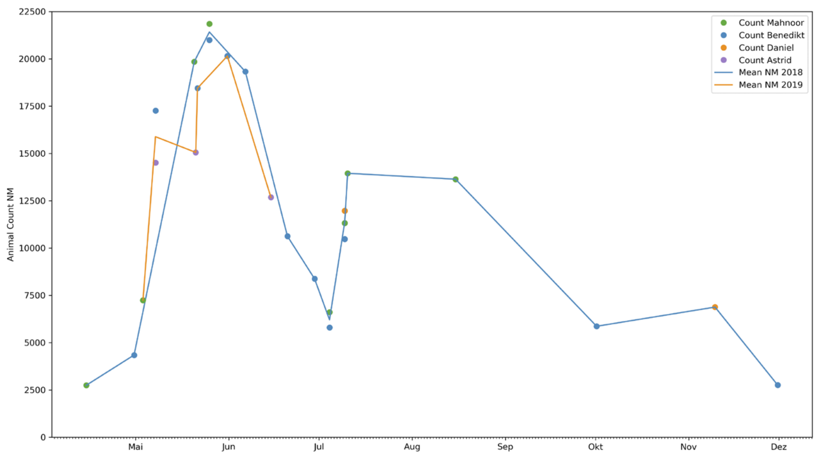

Fig. 4.5.6: Colony occupancy during Autumn 2018 and 2019 at Atka Bay

4.6 PALAOA – Ocean acoustics

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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 depth. 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* from 28 Dec 2014 until 31 Dec 2014 by *Polarstern*, an aluminium 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 (80cm x 60cm x 60cm) 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.* However, based on the experience from the *Neumayer Station III* staff, a servicing interval of approx. 3 months proved to be necessary and was attended to by *Neumayer Station III* staff during the past 3018/19 Antarctic Season.

On January 13, 2019, during this year's *Polarstern* supply of *Neumayer Station III*, the box was maintained and the recording quality was checked. With the ice shelf advancing by about 150 per year, the position is constantly changing. On 13 January 2019, the following positions were recorded:

Hydrophone	70°30.258'S	008°12.717'W
PALAOA station (recording unit)	70°30.402'S	008°12,703'W

The station continues to be in operation, with the hydrophone being located some hundreds of meters from the ice shelf edge.

Preliminary results

PALAOA has been operating quite successfully in 2018 (Fig. 4.6.1) with uptime close to 100 %, except for the November December 2018 period when a few files appear to be missing. Data quality – evaluated on basis of unsystematic samples, is unmarred. A scientific analysis of this year's data has not yet commenced.

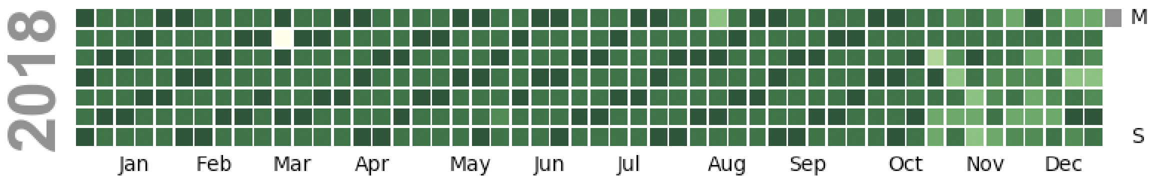

Fig. 4.6.1 Number of 10-min files per day as recorded by PALAOA (max 144)

Data management

PALAOA 2018 data have been transferred from *Neumayer Station III* to AWI and uploaded to "ingest" server (/isibhv/ingest/station/neumayer_iii_palaoa_obs/sv/exdata) from where they have been transferred to the OZASRV server while being renamed to the format YYYYMMDD-hhmmss_NM3-2018_PALAOA.wav. The folder structure is by day at its lowest level and sorted according to NM3-2018_PALAOA/YYYYMM/YYYYMMDD/. As a next step, metadata will be embedded within the *.wav files and files will be migrated to the final OZASRV folders before being archived and promoted via World Data Center PANGAEA Data Publisher for Earth & Environmental Science (www.pangaea.de).

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

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David Dinges[1], Hanns-Christian Gunga[2],
Ruben Gur[1], Simone Kühn[3],
Brad Nindl[4], David Roalf[1],
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[5]NASA Johnson Space Center

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 project leverages the NIMH Research Domain Criteria (RDoC) heuristic framework to conduct experimental studies to identify biological domains (molecular, circuitry, physiology) and behavioural domains that relate to individual adaptation and resiliency (as well as behavioural vulnerability) (Maestripieri & Lilienfeld, 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 focus on neural circuits facilitates the examination of observed individual, phenotypic 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 & Cuthbert, 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 behavioural health during long-duration missions. The project will be based on a close cooperation between the Polar Institute for Polar and Marine Research and several renowned international partners, including Charité, 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 and 2019/20. 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 behaviour 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.

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 behaviour (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.

Data management

Data will be analysed at the PI's laboratory at the University of Pennsylvania and Charité Berlin. 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).

References

Maestripieri D & Lilienfeld O (2016) Using the NIMH Research Domain Criteria (RDoC) in human and nonhuman primate research. Psychophysiology, 53(3), 367-371.

Morris SE & Cuthbert BN (2012) Research Domain Criteria: cognitive systems, neural circuits, and dimensions of behavior. Dialogues Clin Neurosci, 14(1), 29-37 (2012).

Palinkas L A & Suedfeld P (2008) Psychological effects of polar expeditions. Lancet, 371, 153-163.

4.8 Kottas-Kohnentraverse-Dichte 2018/2019

Olaf Eisen, Sophie Berger, H. Hoffmann AWI

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. While measurements of snow accumulation can be easily determined in the field, in our case as part of the project "Kottaspegel", the conversion of snow height to actual mass requires knowledge of the distribution of density in the upper few meters of the firn. These were obtained as part of this project "Kottasdichte".

Objectives

The objective of Kottaspegel is to determine the current spatial distribution of snow/firn density 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 24 November 2018 and 30 December 2019, ten snow pit measurements were performed (see map in Fig. 4.8.1 and Tab. 4.8.1). Two of them (Neumayer air chemistry observatory SPUSO and Pegelfeld) were associated to the observatory work at *Neumayer Station III*. Densities were determined either by weighing conventional metal snow cylinder of 19 cm length and 56 mm diameter or by processing so-called snow liners, as first used in the CoFi Liner Project (Coldest Firn Liner Project, Kipfstuhl, 2017).

Preliminary (expected) results

The snow on Ekströmisen in the vicinity of *Neumayer Station III* (Pegelfeld, SPUSO, HWD1 and HWD2) has densities which varied from 390-490 kg/m^3 at the surface to 440-470 kg/m^3 in 1 m depth below the surface. Numerous ice layers were present, partly up to 10 cm thick (see Table 4.8.1). This variation seems to be related rather to the date of sampling, and thus changing surface conditions like wind crusts, rather than to a spatial trend.

Along the traverse Kottas/Heimefrontfjella to *Neumayer Station III* (KP3-KP6), density varied from 350 - 465 kg/m^3 at the surface to 405 - 590 kg/m^3 at 1 m depth below the surface. On the polar plateau, from Kottas *en route* to *Kohnen station*, density varied from around 325 - 390 kg/m^3 at the surface to 345 - 355 kg/m^3 at 1 m depth below the surface.

In the future it is envisaged to perform density measurements in snow pits regularly as part of the project "Kottaspegel" on a yearly to two-yearly basis. For the scientific interpretation of results, we moreover plan to jointly analyze 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 the World Data Center PANGAEA Data Publisher for Earth & Environmental Science (www.pangaea.de) after primary publication in a scientific journal.

References

Kipfstuhl S (2017) UBA-Abschlußbericht zum Vorhaben „Kältester Firn – Bestes Analogon fuer glazialen Firn (Coldest Firn 2016/17)“, unpublished, 5 pp.

Tab. 4.8.1: Density measurements along the Kottas-Kohnen traverse 2018/2019

Name	Date	Latitude	Longtitude	sampling method	Density surface, kg/m³	Density 1 m depth, kg/m³
Pegelfeld	25.11.2018	-70.68877°	-8.44330°	tubes	410	447
SPUSO	27.11.2018	-70.68087°	-8.27802°	liner	537	452
HWD1	29.11.2018	-70.6577°	-8.1969°	liner	391	467
HWD2	07.12.2018	-70.7537°	-8.79325°	liner	489	442
KP6	30.12.2018	-71.86092°	-8.63425°	liner	447	466
KP5	29.12.2018	-72.78278°	-9.47681°	liner	428	407
KP4	28.12.2018	-73.5822°	-9.3931°	liner	465	588
KP3	27.12.2018	-74.21711°	-9.6801°	liner	347	476
KP2	26.12.2018	-74.70161°	-8.81982°	liner	389	346
KP1	25.12.2018	-75.00493°	-4.2163°	liner	324	354

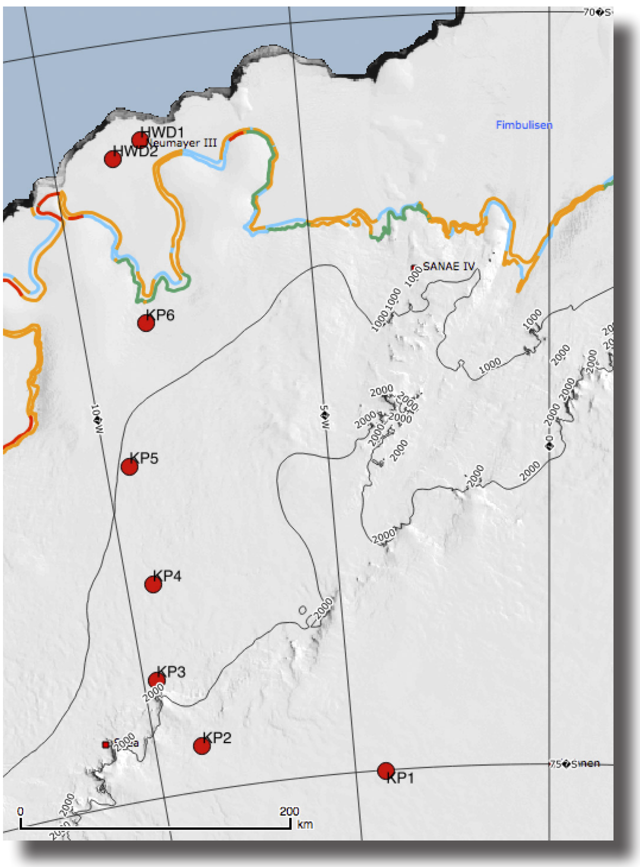

Fig. 4.8.1: Map of snow pits sampled for density (red dots, see Table 1) during the Kohnen-Neumayer-Traverse 2018/19 as part of the project “Kottasdichte”, which is associated to the long-term project “Kottaspegel” for stake readings. Background: MODIS mosaic of Antarctica; 1000 m elevation contours and ASAI grounding lines are indicated as well. HWD refer to Hot-Water-Drilling sites 1 and 2 of the project Sub-EIS-Obs 2018/19 (sampled drill sites EIS-4 and EIS-5, see this volume).

4.9 WSPR RADIO beacon at *Neumayer Station III* for evaluation of southern hemisphere radio propagation

Michael Hartje[1], Ulrich Walter[2]

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Objectives

The objective of this project is to gain more 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 ITU receiving beacon signals from about 1000 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.

When starting the project in January 2018, the first objectives were to install a receiver station at the station's air chemistry laboratory SPUSO with specially designed antennas and a transmitter station with a conventional vertical antenna on the roof of the *Neumayer Station III*.

The planned position of the receiver antenna is shown in Fig. 4.9.1, which depicts only the outer triangle antenna north west of SPUSO.

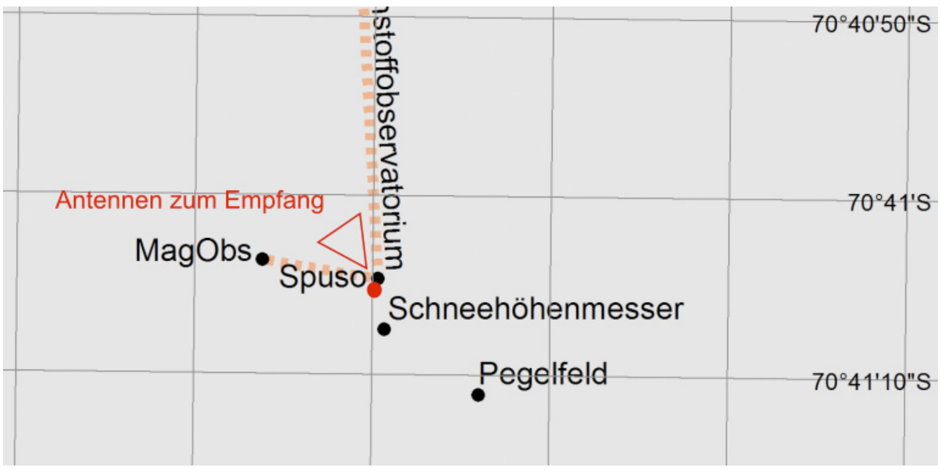

Fig. 4.9.1: Position of the triangle antenna near SPUSO

Fieldwork

The developed equipment was installed by the *Neumayer Station III* personal with the aid and support of AWI. The receiver system at SPUSO comprising two horizontal triangle antennas was installed in January 2018. The triangle antennas have been designed by antenna simulation programs optimized for wave reception from North America, Europe and Australia / East Asia because most potential transmitters are expected to be located there. There are two horizontal triangular antennas, one inside the other. The large outer triangle antenna has a circumference of 160 m, the smaller antenna has 60 m. They were connected to the station room of the SPUSO container via a 1:4 transformer and via 90 m of low-loss coaxial cable. A measurement of the reflection parameters with a vector network analyzer proved, among other things, the correct system setup and the lengths used.

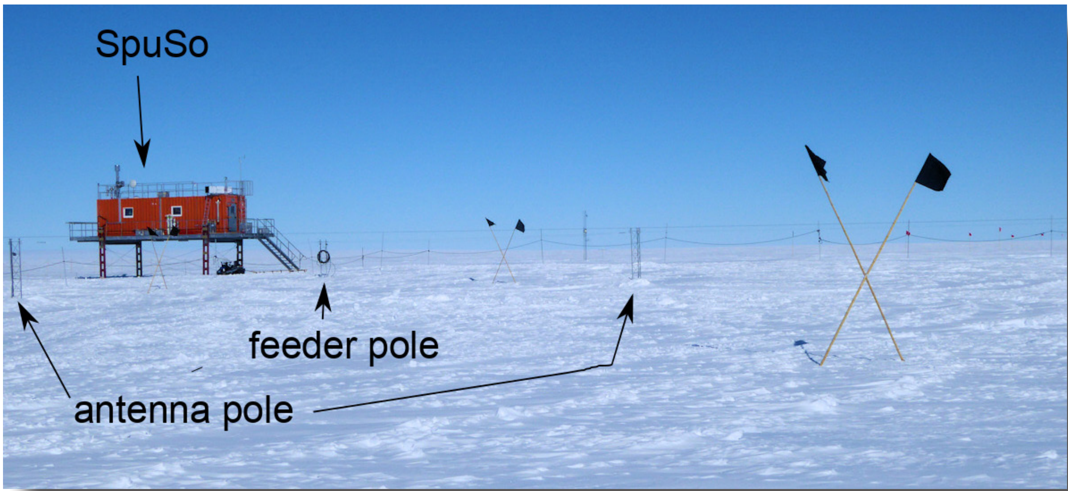

Fig. 4.9.2: Antenna field with the triangle antenna at view point from the north west to the feeder pole

Fig. 4.9.2 depicts a North-West view from inside of the outer triangle down to the feeder pole and shows that the antenna wires are only 1.5 m above the snow level. The feeder pole includes a reel-up reserve for the low-loss coaxial cable.

In the station room, the antennas are connected to the two preamplifiers and those to the inputs of the receiving system. The receiving system uses a Software Defined Radio (SDR) system with a Red Pitaya FPGA programmable measurement device. Due to the low electromagnetic noise caused by very few humans in Antarctica, the preamplifiers were tuned to a high gain – a remote adjustment up to 55 dB amplification is possible. Also the SDR-Red Pitaya is completely remote controlled. The SDR systems FPGA is parametrized for 8 independent receivers, which can be operated in parallel on different frequency bands dependent on the time of day and time of the year.

A second portion of experiments includes a small transmitter for frequencies from 5 to 18 MHz, which – due to the limited mounting of antennas – were installed directly at *Neumayer Station III*. A vertical antenna with 4.5 m length was installed on top of an already existing antenna tower on the roof of the *Neumayer Station III* together with multi-frequency adaption network for the selected frequency range. Impedance matching measurements of the antenna system with the adaption network and worldwide spot results of the beacon emissions (see figures below) confirmed that the radiation of the transmitter antenna was acceptable for the receiving stations world-wide.

Preliminary results

During the period of use from late January 2018 until end of December 2018 the receiver system showed a good and very reliable performance of the antennas as well as with the remote-controlled receiver system.

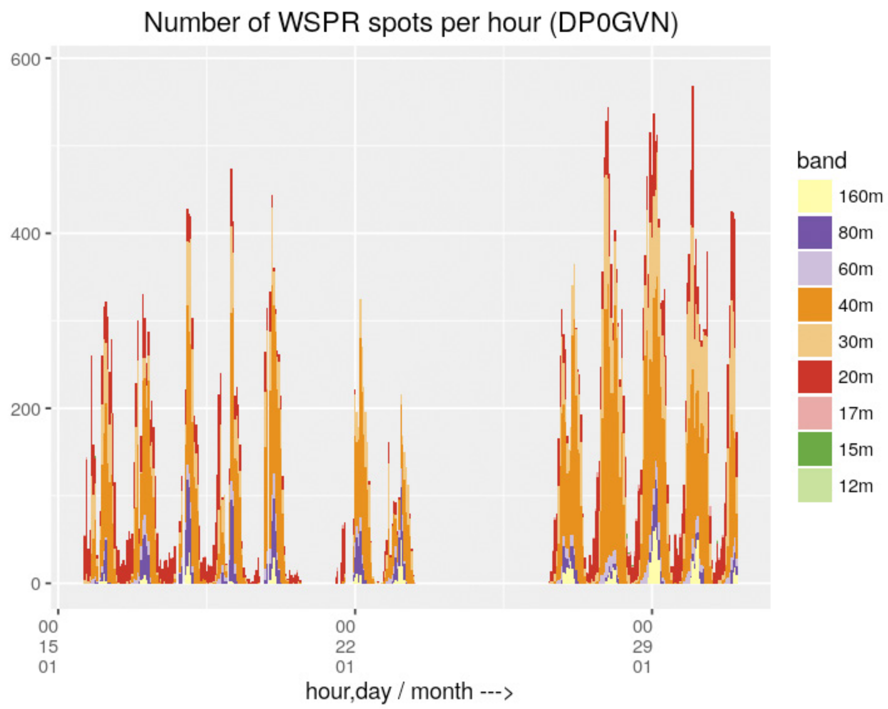

Fig. 4.9.3: Distribution of reported spots per hour from the receiver at SPUSO during the first days of operation in 2018

Fig. 4.9.3 shows the number of spots per hour with different radio bands received at SPUSO during the first days of operation. Due to the time of year and the related propagation conditions for the short wave bands used, this representation shows significantly more spots than expected.

Surprisingly, during the first days of January and February, a significant though unexpected number of spots at 1.8 MHz (160 m) were reported. This is unusual because the receiving station was still on polar day at that time. Hence, at low frequencies, the D-layer in the ionosphere is responsible for large attenuation. The distances up to 13,000 to 17,000 km, require several hops, so that the D-layer has been traversed several times for the distant hops and the reflection at the F-layer.

The WSPR beacon protocol requires all devices to be synchronized with the coordinated universal standard time UTC with a deviation of maximal 4 s. While this was obtained for the receiving system, the transmitter is synchronized with its own GPS-receiver. It was found that the GPS receiver did not synchronize frequently enough. Therefore, at times the internal time reference ran over several days without synchronization. A time drift of about +0.17 s per hour therefore led to long periods during which deviations occur more than 4 seconds.

The time deviation evaluated from the packets of the transmitter at *Neumayer Station III* received at the SPUSO are shown in Fig. 4.9.4.

From Fig. 4.9.4 it can be seen that from March 6, 17:00 h, until March 27, 21:57 h, no transmitted signals were received. The reason for this has not yet been fully clarified. We assume that the transmitter, which is not remote controlled, did not work correctly during this time.

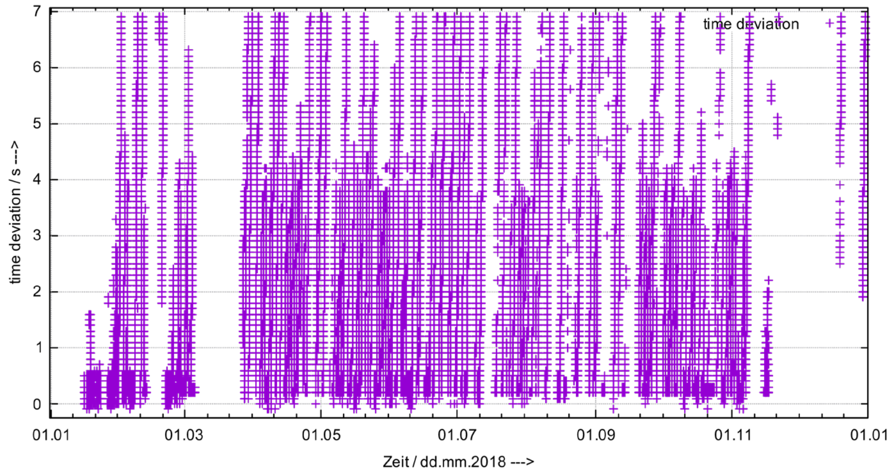

Fig. 4.9.4: measured time deviation of the transmitter at Neumayer Station III during 2018 at SPUSO-receiver

Remarkably, the reception of the transmitter at *Neumayer Station III* at the SPUSO receiver station at distance of about 2 km was possible for deviations up to +7 s. This has not been further investigated yet. There are conjectures that this reception was possible owing to the high signal strength measured there and because the wspr signal includes a high Forward Error Correction (FEC), which makes a correct decoding possible even if only very few parts of the message were received

A new and better GPS antenna outside *Neumayer Station III* was installed in January 2019. This enables continuous time synchronization since then.

In 2018, a total of 96,052 spots were registered by the transmitter at *Neumayer Station III* at SPUSO. These spots have not been registered in the wsprnet.org database. On the other hand, in 2018, the transmitter was reported 131,499 times to the wsprnet database by receivers all over the world. This was partly due to the partially defective transmitter, especially in March and December, and partly due to propagation conditions of the ionosphere during the solar spots minimum.

For the next period in 2019 we expect an increasing number of spots due to a better conditioned transmitter.

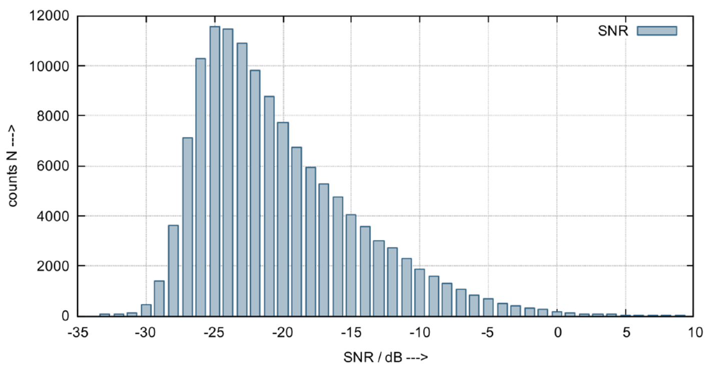

Fig. 4.9.5: Distribution of the signal to noise ration of world wide received reports from Neumayer Station III transmitter during 2018

During operation time in 2018 the receiver station at SPUSO reported 879,094 accepted spots from worldwide transmitters to the wsprnet database. The aforementioned 96,052 spots of the *Neumayer Station III* transmitter were subtracted from this number in the database. Fig. 4.9.5 shows the distribution of the reported signal to noise ratio (SNR) of the world-wide receivers. The SNR is calculated with a reference noise band width of 2.5 kHz. As shown in the Fig. 4.9.5 some receivers report SNR down to -34 dB. As a new release in November 2018 of the decoder software improved the decoder by 3 dB, it is expected, that only a few reporting receiver stations use this new release.

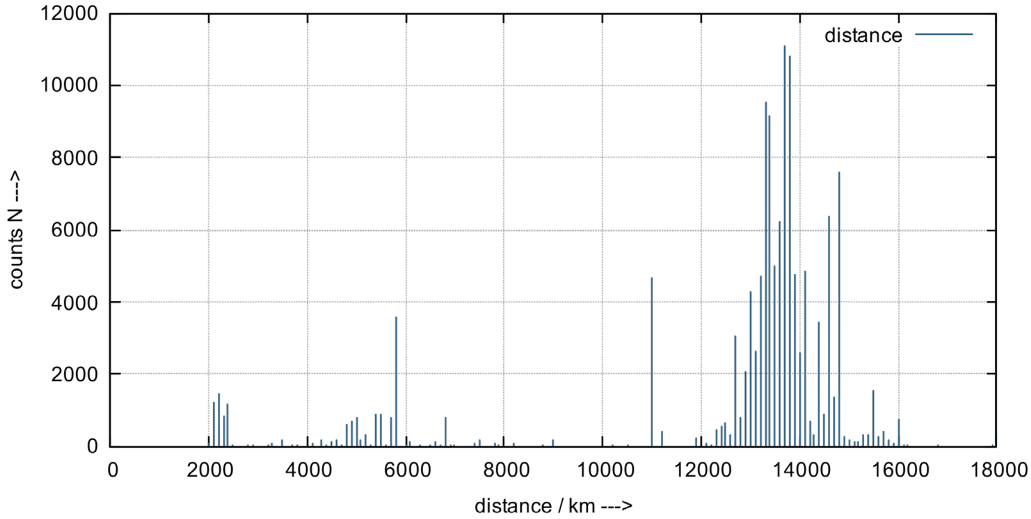

Fig. 4.9.6: Distribution of the distance of the reporting stations to Neumayer Station III

As shown in Fig. 4.9.6, most reporters who received signals of *Neumayer Station III* are at distances of 13,000 km. Maximum distances were up to 18,000 km, and only a few reports were form the southern hemisphere with distances less than 10,000 km. The mean value of the distances to the reporting stations was 12,577.6 km.

In turn, the mean distance of the distant transmitters to the receiver station at SPUSO was 12,092.4 km. Both mean values exclude the SPUSO receiver spots of the close transmitter at *Neumayer Station III*.

The planning of the beacon system was based on the assumption that most of the counter stations would be at distances more than 10,000 km away. These assumption was corroborated by the measurement results as presented in Fig. 4.9.5 to 4.9.7 for the year 2018.

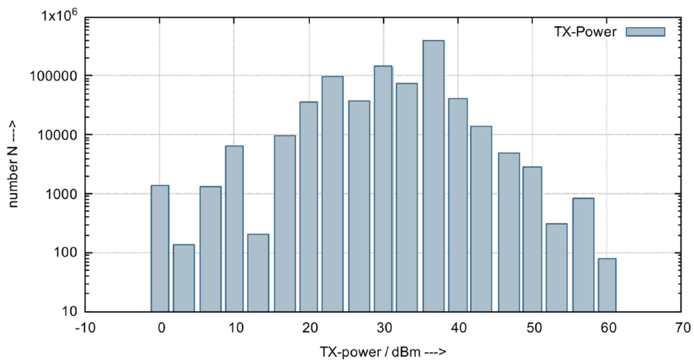

Fig. 4.9.7: Distribution of transmitter power for the received stations at SPUSO receiver.

Fig. 4.9.7 shows the distribution of the transmitter power of stations received at the SPUSO receiver. This power level value is transmitted with the wspr protocol message. It shows, that most stations are using up to 5 W (+37 dBm), but also a significant number uses power levels with 10 W up to 100 W. – The recommendations for the wspr transmitters are to use less than 5 W output power as wspr is specified to be a low power mode. On the other hand, Fig. 4.9.7 shows that many reported spots are from transmitters using equal or less than 100 mW (20 dBm) down to 1 mW (0 dBm).

Griffiths & Gloistein (2019) report received spots from the transmitter at *Neumayer Station III.* The publication was written without consultation with the beacon team and hence convincingly shows that the beacon broadcasts are used by interested researchers. However, due to the transmitter's downtime, it was not yet possible to establish a fixed relationship between the received spots from *Neumayer Station III* and the propagation conditions as well as the bridged geographical distance.

As a side effect, the installation of the beacon transmitter and receiver at *Neumayer Station III* has been very positively remarked in the worldwide amateur radio community. The fact that some stations in the northern hemisphere with a few milliwatts transmitter output power have been received constantly and quite solid at the SPUSO, led to many positive comments, such as: "...the penguins hear everyone…"

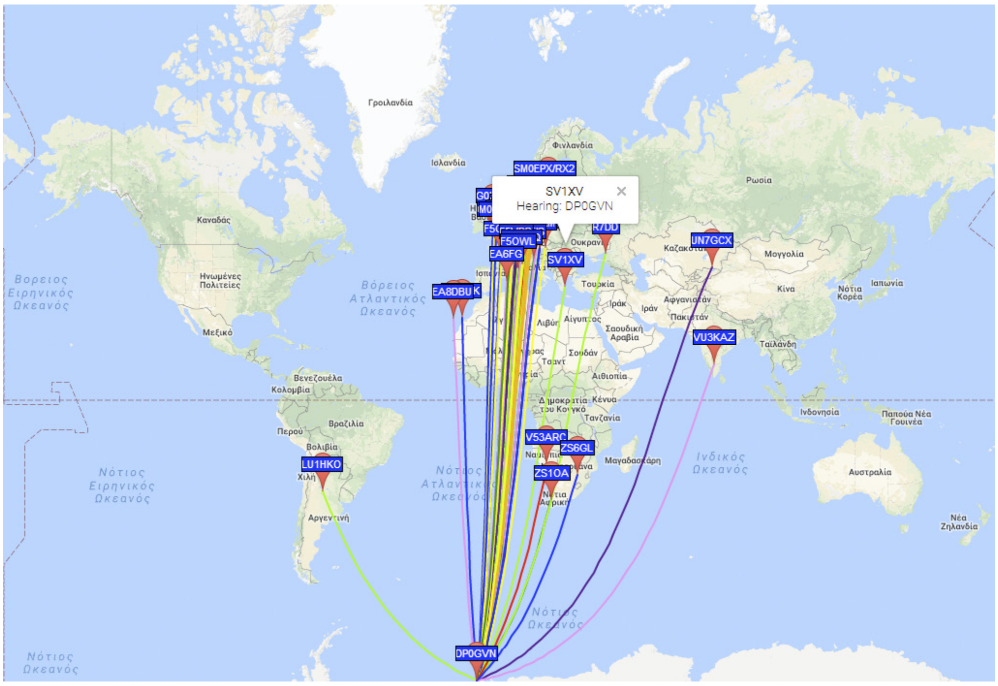

Fig. 4.9.8: World map view of the last 10 min spots at 10 MHz on January 22, 2018 19:36 h

Fig. 4.9.8 shows a map view of the spots reported to the wsprnet.org database as of January 22, 2018 19:36 h for the past 10 minutes on 10 MHz (30 m) band when DP0GVN, the callsign of the beacon transmitter and receiver at *Neumayer Station III,* was selected. When DP0GVN became active, there were a lot of hams radio amateurs world-wide, who were keen to reach this station and to get a report (spot) for their transmission.

An explanation for the extreme sensitivity of DP0GVN to the signals of many low power ham radio stations could be that man-made noise, such as powerline communication (PLC), VDSL vectorization, and unspecified LED lights that do not comply with electromagnetic interference (emi) regulations, do not occur in Antarctica. Both individually and in the superposition of many of these systems increase the resulted noise level on the heavily populated continents while these systems will have practically no part in Antarctica and therefore a significantly lower noise level is to be expected.

Data management

The data from the receiver is stored locally on a flash card and fed into a database at wsprnet.org and at wsprlive.net with world wide access. Both offer archive function as well as basic evaluation functionality. The wsprnet.org-archive collects all received reports since 2008. At 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.

References

ITU-Radiocommunications SG03 (2019) Methods for predicting propagation over the surface of the Earth. In Questions 202-4/3. Jul 2019. [Online; accessed 7. Jul. 2019], http://www.itu.int/pub/R-QUE-SG03.202.

ITU-Radiocommunications SG03 (2018) Radiowave propagation. Jul, 2019. [Online; accessed 7. Jul. 2019], https://www.itu.int/pub/R-QUE-SG03/en.

Griffiths G & Gloistein M (2018) Investigation of 10 MHz propagation from DP0GVN, Antarctica to GM0HCQ/MM on a voyage from the Falkland, Aug. 2018. [Online; accessed 17. Aug. 2018], DOI: 10.13140/RG.2.2.11382.86089.

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. Special thanks go to Felix Riess, Dr. Matthias Maasch 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.

4.10 DROMSEIS – Dronning Maud Land seismological network

Tanja Fromm, Alfons Eckstaller (not in field), Jölund Asseng (not in field) AWI

Objectives

The DROMSEIS project is a temporal seismic network in the Dronning Maud Land (Fig. 4.10.1, left panel) for increasing the detectability of local seismicity. Local seismicity patterns reveal neotectonic activities, indicate events caused by postglacial uplift of the lithosphere and provide a data basis for investigating the thickness of the Earth's crust and principal physical structures of the Earth's upper mantle. Combining seismological results with aeromagnetic and aerogravity surveys produces new insights in the tectonic characteristics of DML on a regional scale and the geological evolution of different tectonic units. A dense station coverage also provides a large data set for studying numerous aspects of cryogenic seismicity caused by ice movements.

Fieldwork

The DROMSEIS seismological stations were set up during season 2017/18 in Western Dronning Maud Land mainly along the traverse from *Neumayer Station III* to *Kohnen Station* (Fig. 4.10.1). After the first year of data acquisition we planned maintenance and data retrieval of the four-autonomous seismographic station with the mid-season traverse from *Kohnen Station* to *Neumayer Station III*. Because of technical issues we removed the three stations DS2, DS3 and DS5. The remaining station DS4 at Forstefjell nunatak was in good shape and continues operation as a long-term station for the permanent observatory network. The station was serviced by helicopter flight from *Neumayer Station III* during the *Polarstern* visit.

Preliminary (expected) results

The extended seismic network in DML increased the number of detected events by about 33 %. Fig. 4.10.1 displays an event exclusively detectable by the extended network and shows the good data quality of the recordings.

Data management

The data will be published via Geofon (https://geofon.gfz-potsdam.de/doi/network/AW) after the analyses will be completed.

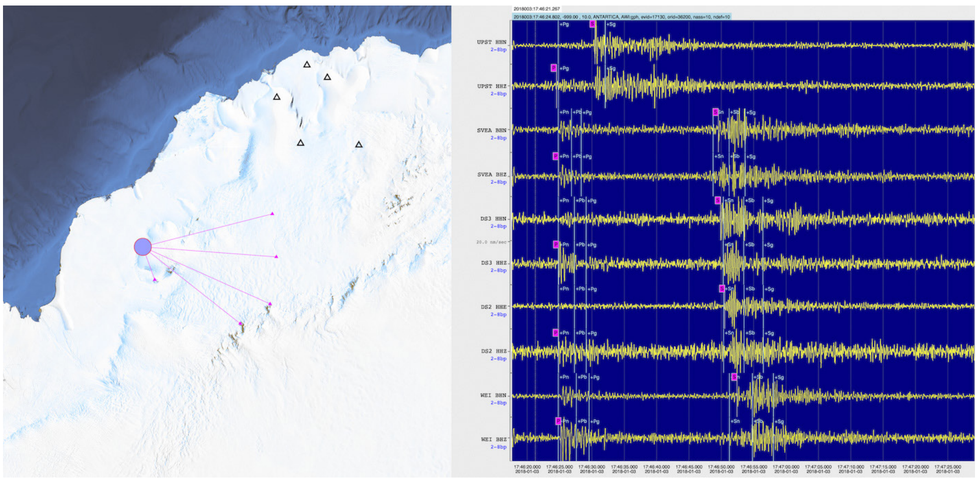

Fig. 4.10.1: Example for a local seismic event. Left panel shows a map with event and station locations. Symbols: Large circle: event location; pink triangles: stations recording the event; black triangles: other station not recording the event; Right panel shows the recorded waveforms, filtered with 2-8Hz bandpass filter. Blue lines: theoretical phase arrivals; Pink letters: picked arrivals. Traces are aligned for theoretical p-wave arrival.

4.11 EDEN ISS

Vincent Vrakking[1], Daniel Schubert[1], Paul Zabel[1], Conrad Zeidler[1], Matthew Bamsey[1], Markus Dorn[1], Giorgio Boscheri[2], Robert Ferl[3], Anna-Lisa Paul[3]

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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. Bioregenerative 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's 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 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: 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 bioregenerative life support systems for planetary surfaces (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

Fieldwork

ANT-Land 2017/18 Neumayer Station III summer field season

The ANT-Land 2016/17 *Neumayer Station III* summer field season was utilized to install the EDEN ISS elevated platform and install the large power cable and fiber optic cable running from *Neumayer Station III* to the platform. Having completed these activities the previous summer field season helped accelerate the actual EDEN ISS deployment schedule during the ANT-Land 2017/18 summer field season. The deployment team arrived at the station via aircraft on December 20, 2017. The original planned arrival date of the EDEN ISS containers was ca. December 26, 2017 but due to weather and ice conditions, this was pushed back to January 3, 2018, when the *S.A. Agulhas II* arrived in the *Neumayer Station III* vicinity and off-loaded the three EDEN ISS containers.

The initial deployment activities of the EDEN ISS containers involved the following:

- Parking of the containers in the direct vicinity of *Neumayer Station III* to empty a wide range of project supplies into *Neumayer Station III* (e.g., laboratory supplies, dangerous goods, temperature sensitive supplies).
- Pulling of the containers ca. 400 m to the EDEN ISS elevated platform. The Service Section container and FEG container were parked directly beside the platform while the blue transport container was parked ca. 20 m from the platform.
- Organizing supplies and setup of the blue transport container as a temporarily work space.
- Removal of the container transport walls.
- In conjunction with the AWI construction team, the Service Section container was temporarily installed onto the elevated platform and then removed so that the container twist locks could be welded to the platform.
- Re-installation of the Service Section container.
- Installation of several pieces of the container to container interface hardware that were required to be installed prior to the final placement of the containers together (subfloor air ducts, pull FEG disconnected cables back through the Service Section to FEG separation wall, prepare four containers to container interface bolts).
- Placement of the FEG container onto the platform to ensure the container to container fit was appropriate.
- Removal of the FEG container from platform and welding of the container twist locks.
- Re-installation of the FEG container onto the platform and tightening of the bolts connecting the two containers.

The AWI construction team assisted the EDEN ISS team on-site during ANT-Land 2017/18 with the installation of the greenhouse containers on top of the platform, with the raising of the platform and with a number of other minor issues.

Although perfect alignment of the containers was not possible, following several attempts of readjusting the FEG container with respect to the Service Section container, a suitable container to container interface/alignment was achieved. The completion of the installation of the containers onto the platform also allowed the large *Neumayer Station III* crane to be used to install the free cooler and roof ladder onto the top of the Service Section container. This was followed by the installation of a wide array of external hardware and removal of some final transport hardware (e.g., window covers, covers for cable/pipe pass-throughs). The following overview timeline presents the main on-site activities that were conducted during the EDEN ISS deployment phase:

Week 1 (January 4 - 10)

- Install of containers on platform
- Setup of communications hardware in the *Neumayer Station III* multipurpose laboratory
- Installation of external hardware including, roof ladder, free cooler, free cooler cooling fluid pipes, cable channels, CO_2 distribution system, external lights, door bumpers, small stairs, chimney H-cowl, roof safety rails, cable and piping pass-throughs (rubber) in external walls
- Complete the connection of the *Neumayer Station III* to MTF power cable
- Setup of the energy monitoring system sensors in the power box
- Unpack tools in the MTF
- Activate internal heaters
- Complete air duct, nutrient delivery system (NDS) and thermal control system piping interface connections
- Insulate the container to container interface

Week 2 (January 11 – 17)

- Install patch antennas on the MTF and on the *Neumayer Station III*
- Complete Argus sensor wiring
- Fill the thermal control system with cooling fluids
- Complete air management system setup (install filters)
- Illumination system operational
- NDS tray installation, fill NDS with fresh water and perform leak check
- Complete the basic setup of the multipurpose laboratory in *Neumayer Station III* (e.g., reverse osmosis system operating)
- Command and data handling system setup and testing
- Testing of the gas safety system
- Arrival of the second part of the EDEN ISS deployment team (January 13)

Week 3 (January 18 – 25)

- Complete CO_2 distribution system connections
- Installation of CO_2 flowmeter
- Test of air management system and thermal control system via software
- ISS rack-like (ISPR) plant growth system setup

- Improve FEG atmospheric closure (tape air ducts, insulate/better seal connections)
- Insulate external cable and piping pass-throughs
- Raise platform and installation of primary platform stairs
- Improve the structural rigidity against wind of the free cooler electronics box by installing a metal brace
- Install the multi-wavelength imagers for plant health monitoring

Week 4 (January 26 – February 1)

- Employ the TransMADDS for cleaning/decontamination of the FEG
- Antarctica to Europe communication troubleshooting
- First planting in the MTF
- Troubleshooting of various MTF subsystems (external lighting, CO_2 delivery)
- Continued ISS rack-like plant growth system setup and testing
- Calibration and final testing of various sensors (pH, electrical conductivity, condensate collection, CO_2 flowmeter, leak sensors)
- Installation of protection for the fiber optic cable as it runs along the external platform
- Prepare the FEG nursery
- NDS fully operational

Although troubleshooting of various subsystems continued into early February, increased focus was placed on testing and readying the MTF for overwinter operations. During this phase, seeds were germinated within the dedicated nursery of the FEG. Further MTF initiation directed activities included:

Week 5 & 6 (February 3-14)

- Initiation of control system/enabling all system alarms and appropriate thresholds
- CO_2 leak test within FEG and ISS rack-like growth chambers
- Planting of the first crops in the nursery (start of germination)
- Final teach-in of EDEN ISS overwintering crew member (Paul Zabel) on various systems
- Last sensor calibration within the air management system
- Solving of additional Argus control problems
- Inventory and final reorganization of spares and supplies within the station and the MTF
- Start germination process within the ISPR
- Test of multi wavelength imagers with maturing plants
- Test of communication lines between MTF and *Neumayer Station III* as well as to the Mission Control Center in Germany
- Troubleshooting of microbial contamination issues within the nutrient solution during the ramp-up phase

Although the EDEN ISS containers were delivered later than planned, the actual on-site deployment activities shadowed the timeline and the actual activities that were included in the field plan developed in the lead-up to the field season. So although the MTF facility was in the anticipated/planned state at the time of departure of the deployment team, there were several unexpected events that occurred during the field season and a subset of these off-nominal issues are described here:

- Service Section to FEG door not opening fully

  As described previously, great effort was placed on getting the Service Section and FEG containers to line up properly on the elevated platform. The final result was that the containers were approximately 1 to 1.5 cm further separated from each other than they were in Bremen before deployment to the Antarctic, and that one container was angled slightly with respect to the other. The latter was apparent from the perspective that the Service Section to FEG door (installed on the frame of the FEG container) could not be fully opened, as it would bump directly into the Service Section floor. Several adjustments had to be made to the door, the first was that it was moved up as much as possible on its hinges and the rubber installed on the underside of the door was removed. As removing the rubber insulation on the bottom of the door reduced the atmospheric closure of the FEG, a permanently installed bar including a band of rubber insulation was installed directly onto the floor of the FEG. When the door was closed it would push up against the rubber and seal the door connection.

- External damage to the underside of the containers during transport.

  Although only first noticed following the installation of the containers onto the elevated platform, it was evident that the Service Section and FEG container bottoms had been pierced during transport to Antarctica. Although one of the two damage locations was significantly deeper, both were insulated with spray foam and then taped over with aluminium tape.

- Leaks in the thermal control system and NDS piping.

  Several leaks in the plastic piping of the thermal control system and NDS were found during early testing/leak checks of these systems with water. It is obvious that the transport to Antarctica was the primary reason for these leaks but as they were somewhat minimal, the project would not have taken any additional pre-shipment measures to reduce the number of leaks that were apparent. These leaks were fixed either by removing a section of piping and installing a freshly glued section or applying additional glue to the connection in question. That said, as one of the leaks of the thermal control system occurred from a union connection, it is suggested that following long duration transport, such as that which occurred with the EDEN ISS containers, that all union connections should be checked/re-tightened prior to system initiation. Although this was already a known issue with the tightly compact thermal control system rack, a lesson learned that should be carried over to future greenhouse system designs is that all connections should be better accessible and system racks should not be built in such a compact manner if they limit access to all installed components. Thus in addition to providing better access to all connections following shipment, this would simplify repairs and maintenance activities on the thermal control system (on-site maintenance and repair should always be considered a high priority in subsystem design).

- Removing air from the thermal control system.

  Several issues arose in the initial operation of the thermal control system in which the appropriate cooling fluid temperatures in the thermal system could not be maintained. Although considerable time was spent manually releasing air via the various thermal system air release valves, it was obvious that further air was trapped within the roof-top free cooler and this was resulting in less optimal heat transfer. As the free cooler was only used for several hours in Bremen (due to the summer weather during the Bremen test phase) and a large standalone electric cooler was used, such issues were not observed during the assembly, integration and testing phase. The opening and closing of the various air release valves during the Antarctic deployment phase resulted in one of the air release valves breaking. In particular, although the valve could be reclosed it could not be reopened to release air as otherwise a leak of the Tyfoxit F50 cooling fluid would permanently occur. A project decision was made to change the air release valve while the full deployment team was on-site to reduce the possible heavy workload for the single overwintering operator should this air release valve be further required. Additionally a solid protocol for getting the air out of the free cooler loops was developed which involved adjusting thermal control system pump settings and manually opening and closing the various other valves in the system, both of which helped force further fluid though the system and further dislodging any remaining air bubbles.

- Blockage of flow through the secondary CO_2 regulator

  Although detailed analysis showed that problems due to low temperature were not likely to arise with the CO_2 distribution system even if it were to be placed outside the MTF, on several of the cold days of the deployment phase it was observed that even with the internal CO_2 solenoid valve open, no CO_2 would flow into the FEG. Following leak checks, testing and additional observations, it was concluded that this was a result of CO_2 freezing up within the secondary regulator of the CCO_2 distribution system (Linde W20/B regulator with 0.5 to 10.5 bar output, part number: 7616606). When a small amount of heat was applied to the regulator a small grain of CO_2 ice could be heard as it was dislodged and CO_2 could then flow again. To combat this problem, a small electric heater was installed directly onto the regulator body and a minor amount of insulation added. Control logic was built into the Argus control system to activate the heater on a set schedule and no additional blockages in the CO_2 delivery system were observed.

- Microbial contamination in the NDS

  Early in the deployment the NDS was filled with nominal *Neumayer Station III* water to test the system for leaks. This water was later drained and the system refilled with reverse osmosis water and concentrated hydroponic stock solutions added to their respective NDS tanks. Several NDS check-out tests were conducted to ensure that the system could maintain the desired pH, electrical conductivity, tank level set-points while testing NDS hardware in the lead-up to plants being added to the FEG. Plants were added approximately a week later and approximately two days later the team remarked that the solution in NDS tank 1 (salad crop hydroponic solution) was cloudy, had a small amount of foam buildup floating on the surface and was emitting a moderately foul odor. This was followed by the observation of a white/pinkish fungus on the surface of the rock wool plugs that some of the plants were growing in. Images of both the growth tray fungus and state of the hydroponic solution were taken and sent along to the EDEN ISS science team in Europe. Samples were also collected for later analysis. Although the on-site team reacted initially by increasing the duty cycle of the ozone generators feeding the NDS tanks, which resulted in some improvement over the period of a day, considering input from the remote science team and the fact that the deployment team would be departing in less than a week, leaving the on-site operator alone, the deployment team decided that proceeding with a full-system clean-out was the preferred option prior to their departure. The team proceeded in removing all plants from the MTF, draining the entire NDS, cleaning all accessible surfaces (e.g., plant trays, inside of NDS tanks) with appropriate disinfectants, filling the NDS with a concentrated bleach solution and operating all pumps and components for a period of 5 hours. The system was then drained, filled with water, re-drained and left to dry. In conjunction, additional seeds were germinated in the station and the ozone generator settings reassessed and further increased. The results and analysis of the samples returned will be reported upon in a later publication.

- Remote connection issues

  The external communication lines to the MTF control PC (Argus) were not stable and remote access to this control PC (through personnel from Argus or other members of the EDEN ISS project remote operations team) was not possible. This situation lasted several days and the planned upgrades and improvements could not been made to the CDHS. Eventually the situation was resolved by the AWI information technology department by readjusting the firewall settings within the server architecture in Bremerhaven.

In support of the nominal experiment phase, a dedicated laboratory (multi-purpose lab) within the *Neumayer Station III* was outfitted. The laboratory is equipped with tools for microbial investigations, food quality and safety measurements and general equipment for post-harvest analysis. The lab is also used for sample preparation and stabilization. All samples (food quality- and safety related as well as microbial samples) are stored in a mobile freezer at -40°C. A dedicated sample-return strategy was worked out in order to transport the samples back to Europe for further analysis after the experiment phase end (~end of November 2018).

Nominal Operations Phase – 2018/19 Neumayer III winter season

Between March 2018 and December 2018, Paul Zabel was part of the ANT-Land 2018/19 winter season crew and was responsible for the technical and scientific work in, on and around the EDEN ISS greenhouse.

Most of the time was dedicated to nominal operational and scientific activities, such as:

- Seeding of various crops.
- First harvest of four different types of lettuce, Swiss chard, red mustard and radishes on 20 March 2018.
- On 23 March 2018 the first arugula was harvested.
- Following harvest, plant samples were collected and freeze dried for later transport back to Europe.
- Microbial samples were collected from different locations within the greenhouse and frozen for later transport back to Europe.
- The experiment procedures were checked and expanded upon in collaboration with remote experts.
- Harvest of various crops (e.g. lettuce, cucumber, herbs, arugula, kohlrabi).
- Table 4.11.1 provides the amount of fresh edible biomass harvested during the ANT-Land 2018/19 winter season. The vast majority of this biomass was supplied to the station crew and the remaining fraction was stored for later scientific experimentation.
- Initial planning activities for the ANT-Land 2018/19 Summer season.
- Documentation of nominal, off-nominal and scientific work activities.
- Build-out of the ISPR Plant Cultivation Rack from the Service Section container in preparation of transport back to Europe via *Polarstern.*

A total of 72 off-nominal events occurred during the first operations phase, with the majority occurring in the first months of operation. Some of the malfunctions and failures which had to be addressed are listed below:

- A leakage occurred in the thermal control system, which needed to be sealed. Subsequently the leaked fluid needed to be removed and additional coolant had to be added to the system to obtain the desired coolant pressure.
- A heavy storm from 20 to 23 March resulted in minor damage to the exterior of the facility, which was fixed once the storm had passed.
- A failure occurred with a three-way valve actuator in the thermal control system, on 27 April, which was repaired in collaboration with the station engineer.
- On 28 April one of the LED lamps failed and had to be replaced with a spare unit.
- Clogging of one of the filters in the NDS resulted in a temporary reduction in water flow to two of the plant cultivation racks. Cleaning of the filter resolved the issue.
- An air pump which supplied air to the ozone generator in the NDS was making an abnormal amount of noise. The pump was replaced with a spare unit.
- One of the level sensors in the system failed, but could be fixed by the on-site operator.
- One of the two fans of the free cooler unit, which is mounted on the roof of the facility, failed. The fan motor was damaged and could not be repaired and no replacement part was available. Nominal operations could be continued however.
- Two leakages occurred in the thermal control system loop for the LED panels.
- The leaks were sealed, cooling fluid was added to the system to obtain the desired pressure in the loop and the loop was vented to remove any air build-up in the system
- Ice build-up around one of the three-way valves of the thermal control system resulted in a blockage of valve movement. This led to a loss of control over the coolant fluid temperatures, resulting in heavy fluctuations in the internal temperature and relative humidity. Manual removal of the ice around the valve resulted in temporary mitigation of the issue.
- A number of components in the NDS experienced failures and needed to be replaced by spare components.
- In July there was a reoccurrence of ice build-up around one of the three-way valves of the thermal control system and this resulted in a blockage of valve movement. This led to a loss of control over the coolant fluid temperatures, resulting in heavy fluctuations in the internal temperature and relative humidity. Manual removal of the ice around the valve resulted in temporary mitigation of the issue.
- A connection between two piping elements of the thermal control system loosened, resulting in leakage of coolant fluid. The connection was tightened and the spilt coolant fluid was cleaned. Following refilling of the cooling loop and venting of air, nominal operations of the facility could continue.
- One of the high pressure pumps in the NDS failed in September and had to be replaced by a spare unit.
- In October another high pressure pumps in the NDS failed and had to be replaced by a spare unit.
- A sensor used for automatic control of a NDS sump pump failed. As no spares were available, an alternative control approach had to be found and implemented.

An agreement was reached between the Alfred Wegener Institute and the German Aerospace Center to continue operation of the EDEN ISS Facility at the *Neumayer Station III* for at least another two years, through the ANT-Land 2019/20 and ANT-Land 2020/21 winter field seasons.

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

In November and December 2018 operation continued by the on-site operator Paul Zabel. The official end of the first operations phase of the EDEN ISS facility was on 20 November with the final harvest of all crops taking place. Before that, time was dedicated to prepare and execute movie recordings for the German TV show 'Galileo' with a film team present at *Neumayer III*. The time between the final harvest and the departure of Paul Zabel was dedicated to final measurements, data backups, cleaning activities, inventory activities and preparations for the arrival of the summer team in January 2019.

During the ANT-Land 2018/19 summer field season four project members from the German Aerospace Center, and two project members from the University of Florida, stayed at the *Neumayer Station III* for some weeks in January and February 2019 in order to prepare the EDEN ISS Facility for the second operations phase.

In January 2019 the project members carried out the following activities:

- Preparation of the EDEN ISS greenhouse and presentation of the facility to the VIP delegation as part of an inspection tour.
- Documenting the available inventory of spare parts, additional parts for facility upgrade, as well as consumables.
- Harvest of all available biomass and aiding in the preparation of the fresh edible biomass for consumption by the station crew.
- General cleaning of the facility.
- Repair, maintenance and upgrade activities on the Plant Health Monitoring system. This included replacement of various cameras with higher resolution cameras, as well as installation of additional cameras and modification of some cameras with specialized filters.
- Removal of part of the Service Section air management system components.
- Preparation of ready-to-mix nutrient solution bottles for the second operations phase (to reduce the required crew labor/time in making up hydroponic nutrient solutions).
- Installation of a new rack system in the available space previously used to house the ISPR Plant cultivation rack.
- Plant health monitoring experiments, using NDVI, on Kohlrabi plants, prior to harvesting and cleaning of the facility.
- Snow probe collection and analysis to characterize bacterial/microbial contamination around the facility.
- Design of a planting schedule for the second operations phase.
- Modification of the power control and distribution system and the command and data handling system, including installation of new sensors and actuators.
- Exchange of all high pressure pumps in the NDS.
- Exchange of the fans on the roof-mounted free cooler unit.

In February 2019 the project members carried out the following activities:

- Removal of the remaining Service Section air management system components. Installation of new stock solution tanks for the NDS.
- The new stock solution tanks have much larger volumes and as such need to be exchanged less frequently, reducing the amount of work effort needed by the overwinterers during the second operations phase.

- Extensive cleaning of the Service Section container.
- Cleaning and subsequent filling of the fresh water tank and the two bulk solution tanks for the NDS.
- Repair, maintenance and upgrade activities on the plant health monitoring system. This included replacement of various cameras with higher resolution cameras, as well as installation of additional cameras and modification of some cameras with specialized filters.
- Installation of new CO_2 sensors with an increased measurement range of up to 5000 ppm, as opposed to the previous 2000 ppm limit.
- Preparation (packaging, documentation) of return cargo for transport back to Europe.
- Exchange of filters, UV lamps, and other consumables in the facility.
- Repair of the insulation material cover of the thermal control system piping elements on the outside of the facility.
- Cleaning of the condensate water recovery system.
- Installation of a stand-alone dehumidifier in the Service Section container.
- System test of all actuators and sensors.
- Update of the software for data transfer to the Mission Control Center in Bremen, Germany.
- Documentation of available inventory of parts and consumables, available at the end of the summer season, in preparation of the second operations phase.
- Calibration of all sensors.
- Installation of higher resolution Hikvision imaging cameras throughout the MTF.
- Filter modifications to original Hikvision cameras to enable remote control over NDVI imaging.
- Venting of the thermal control system.
- Initial test of a new procedure for seed germination, without the use of a dedicated nursery.
- Labelling of all systems and components in the facility to aid the overwinterers during the second operations phase.
- Instruction of the overwinterers in regards to the design, control and maintenance of the facility.
- Update and finalization of procedures for nominal and off-nominal activities for the overwinterers to use during the second operations phase.

For the ANT-Land 2019/20 winter field season, operational activities will be carried out by the regular overwintering crew selected by the Alfred Wegener Institute. In the absence of a dedicated operator, scientific activities will be reduced throughout the season, in an attempt to limit the required crew effort. Remote support will be provided by the consortium partners to assist the overwinterers with EDEN ISS-related activities.

Preliminary (expected) results

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

Biomass production

Table 4.11.1 shows the amount of biomass harvested each month during the ANT-Land 2018/19 winter season. Initial harvest in March, as well as the final harvest in November 2018 yielded roughly 50 additional kilogrammes, such that, in total, more than 268 kg of edible fresh biomass was harvested during the first operations phase between March and November 2018. Detailed information regarding the biomass production can be found in a dedicated publication (Zabel et al., 2019).

Tab. 4.11.1 Monthly fresh edible biomass harvest during the 2018 winter field season

Month	Fresh edible biomass [kg]
April	31.57
May	42.35
June	32.78
July	21.81
August	35.22
September	26.88
October	27.80

Fig. 4.11.1 shows the distribution of the produced fresh edible biomass across six categories of crops. The cultivars included in each of these categories are listed in Table 4.11.2. The category 'miscellaneous crops' contains cultivars which were grown for test purpose or which did not perform well.

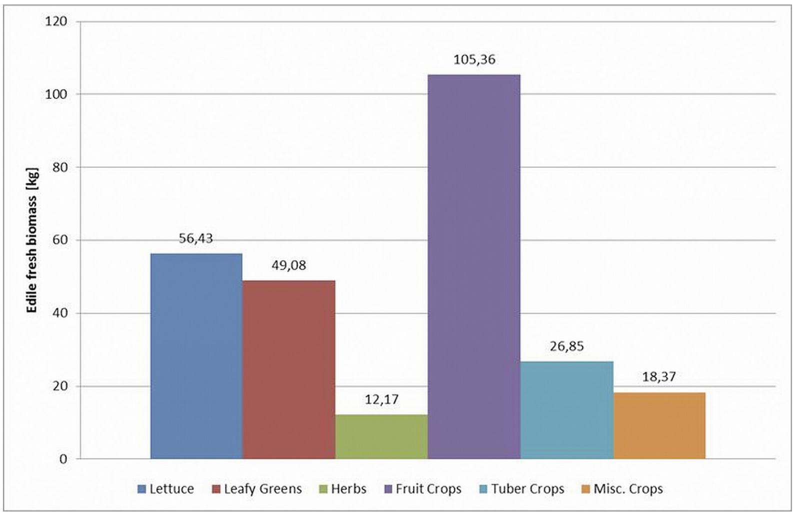

Fig. 4.11.1: Edible fresh biomass produced during the first operations phase per crop category

Tab. 4.11.2: Crop categories and corresponding cultivars

Lettuce	Leafy greens	Herbs	Fruit crops	Tuber crops	Miscellaneous crops
Batavia	Arugula	Basil	Cucumber - Picowell	Radish - Lennox	Cilantro
Expertise	Mizuna	Parsley	Dwarf tomato - Orange F1 3469B	Radish - Raxe	Mint
Outredgeous	Red Mustard - Frizzy Lizzy	Chives	Dwarf tomato - Cherry F1 1202	Kohlrabi	Lemon Balm
Waldman's Green	Red Mustard - Red Giant				Celery
	Swiss Chard				Pepper - 1601-M
					Pepper - Cupid
					Tomato - Bogus Fruchta
					Tomato - Harzfeuer
					Strawberry

A detailed analysis of the variations in edible biomass production for different cycles, as well as the underlying reasons for these variations is still ongoing. Correlation of the biomass output quantity with the results of food quality analyses and the environmental conditions within the MTF is likewise a work in progress.

Resource consumption

The electrical energy demand of the MTF ranged from 6700 to 8000 kWh per month as can be seen in Fig. 4.11.2. The total energy demand from March to November 2018 was around 65,000 kWh. A drop in energy demand in June was mainly caused by the failure of one of the two free cooler fans in mid- May. The remaining fan was shut down from the beginning of June until September, because the low temperatures of the Antarctic environment were enough to cool the cooling fluid without the need of the fans. The rise in energy demand from June to October is most likely associated with the dropping temperatures during the winter months, resulting in an increased heating load. The November value is much lower because the measurements were stopped on November 20.

The overall power demand of the MTF shows a cyclic behaviour, as shown in Fig. 4.11.3, which is caused mainly by the daily cycle of the LED lamps (17 hours on, 7 hours off per day). The average power demand during the photoperiod is 11.24 kW and during the dark period 8.22 kW.

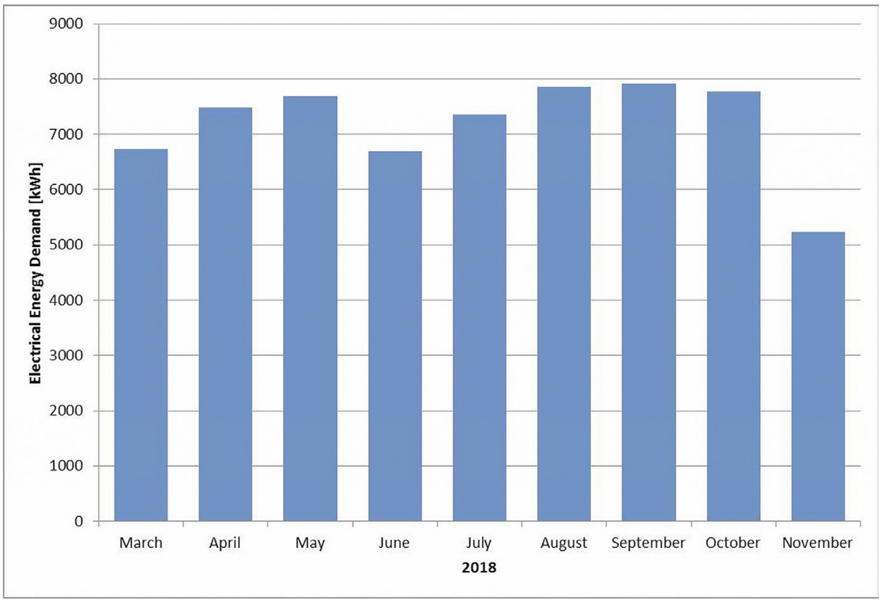

Fig. 4.11.2: Monthly energy demand during the first operations phase

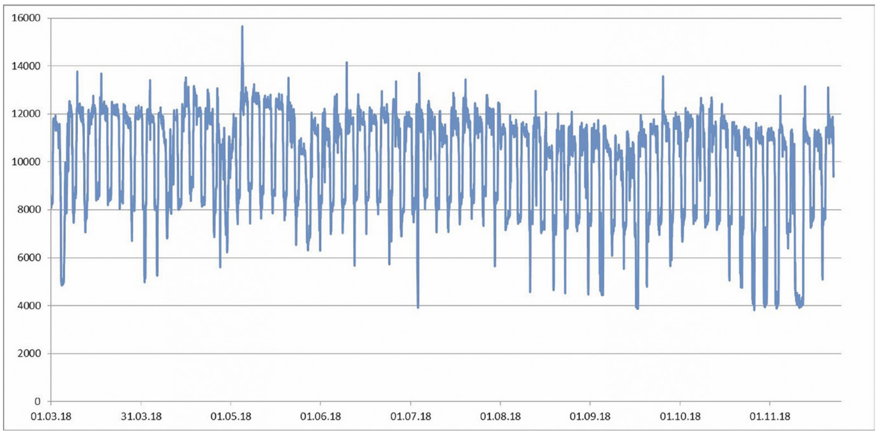

Fig. 4.11.3: Power demand of the EDEN ISS Mobile Test Facility during the first operations phase

Aside from the power and energy demands, the resource input and waste outputs of the facility were tracked. Additionally, the amount of time needed by the operator to manage the greenhouse throughout the operations phase was investigated.

Initial measurements were taken to assess the amount of crew time needed to complete various tasks to allow a better characterization of crew time planning for future space missions and to determine which activities or systems should be targeted for improvement to reduce the overall amount of work effort. Fig. 4.11.4 depicts the normalized crew time per kilogramme of edible biomass, where the crew time is the combined time needed for all crop cultivation, maintenance, repair and science tasks.

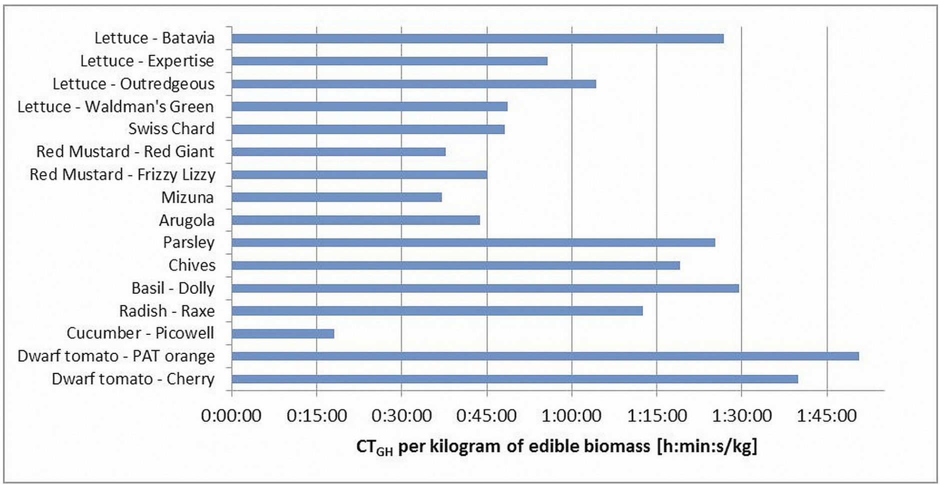

Fig. 4.11.4: Normalized crew time demand per kilogramme of produced biomass

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. These samples were returned to Europe for analysis. Reasoner's 2A (R2A) agar and Potato Dextrose Agar (PDA) agar were used as growth media as part of the microbial contamination investigations. PDA is a standard medium used for growing fungi or bacteria, whereas R2A is better suited to slow-growing species, such as bacteria which might inhabit water.

Full characterization of the microbial environment is still ongoing, but initial results indicate that the overall microbial load is low compared to that found on commercially available produce as indicated in Fig. 4.11.5. Furthermore, the diversity of micro-organisms is much lower than in conventional greenhouses. During the analysis, a comparatively high microbial load was found on samples of parsley, which is thought to be a result of (some of) the seeds being contaminated prior to use in the EDEN ISS Facility.

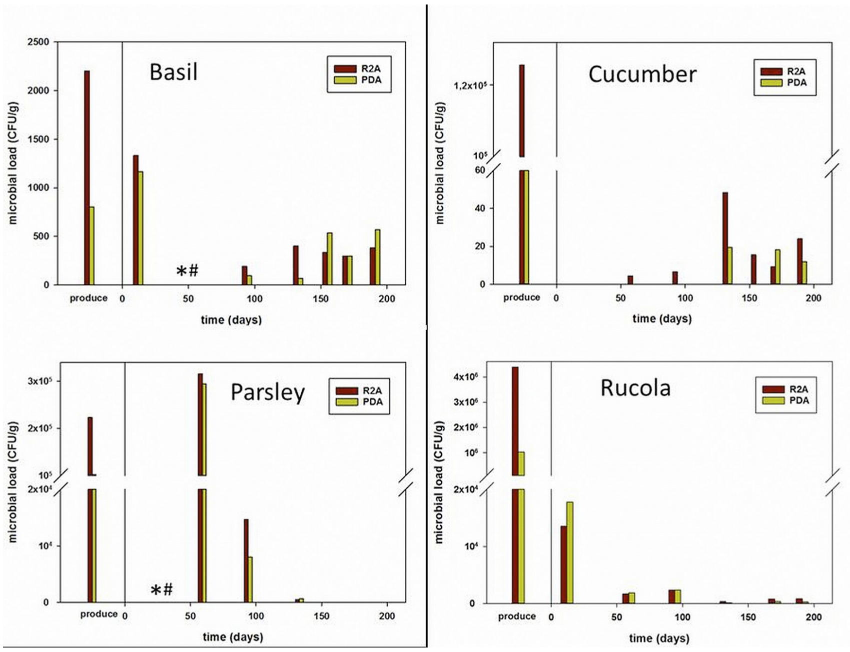

Fig. 4.11.5: Microbial load of commercially available produce and samples from EDEN ISS-produced biomass

Gene sequencing of the samples is planned, for complete identification of the micro-organism strains. Additionally, cross-referencing of the microbial load development over time with specific operational activities of the operator will be done to determine the efficacy of various crew activities in reducing the level of contamination in the facility. This will feed into the improvement of the operational procedures and activity scheduling for future operation phases.

Plant Health Monitoring

The University of Florida (UF) seeks to bring to the EDEN ISS project expertise and experience in plant growth in spaceflight environments, along with spaceflight experience in using specific informative imaging capabilities. In particular the UF team developed dual wavelength spectral imagers and imaging procedures within the EDEN ISS facilities and provide image processing and analysis to provide tele-science support and plant science analytics to better understand the responses of plants to extreme environments and off nominal growth situations, and production support to optimize plant performance (Beisel et al., 2018).

In the first year of operations (2018), UF produced prototype imagers based on the GoPro commercial cameras and assisted in the final installation setup at the *Neumayer III* Antarctic site at the start of the project run. The first generation of UF Spectral Imaging cameras was based on the GoPro Hero4. They were modified to allow near IR into the sensor and a dual wavelength filter to collect both red and Near IR and the Red pixels of the sensor, while green and blue wavelengths are captured by the Green and Blue pixels. The filter blocks all greenish yellow, yellow and orange wavelengths to offer clear separation of the informative wavelengths to the image sensor. The modifications are enabled through the use of the Back-Bone Ribcage mod kit. The resulting images can be easily separated using plugins for ImageJ or other software, and the separated images can be manipulated by pixel math to produce normalized differential images using a wide range of pixel mathematics. Using a single sensor and single filter keeps the visible and near IR images in perfect register, eliminates the need for a mechanical filter wheels in the camera, and keeps the number of images that have to be managed by the data system to a minimum. Fig. 4.11.6 shows a summary of the UF Spectral Imaging (UFSI) system set up.

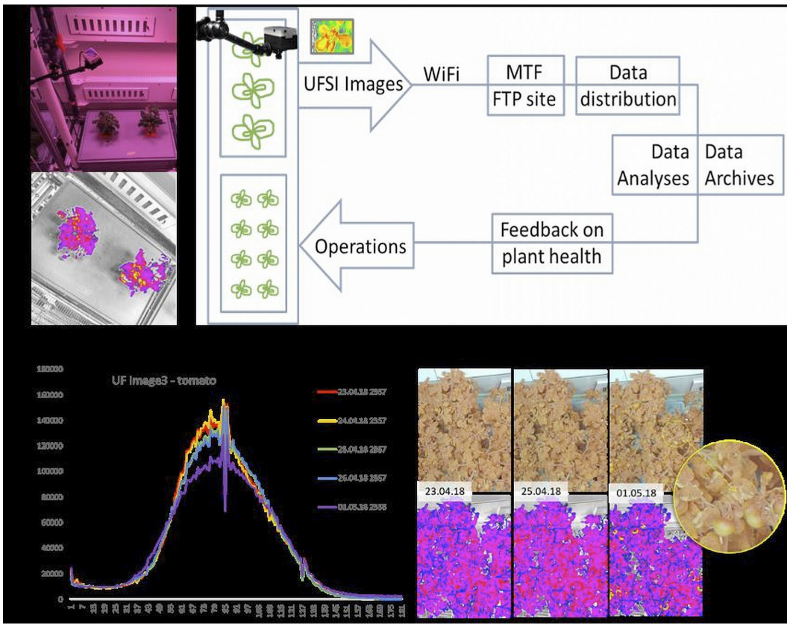

Fig. 4.11.6: (A) The basic information path that was envisioned for the UFSI system integrated into the FEG. (B) An example from May of 2018 where the UFSI system recorded an anomaly in the health of one of the trays of tomato plants in the FEG.

Analysis of the complete image set from the first operations phase is ongoing, but some data from end of April indicates a quantitative decline in plant health for some of the tomato plants, which was not readily apparent to the operator, demonstrating the usefulness of the system.

Psychological investigations

Due to the limited crew size of 10 overwinterers, the psychological investigations 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.

With the operations of the EDEN ISS facility extended for at least two more years, the consortium plans to continue their psychological investigations to gather more data from a larger sample size.

Expected results of ANT-Land 2019/20 Neumayer Station III winter field season

As mentioned, the second operations phase, during the ANT-Land 2019/20 winter field season, will have a reduced scientific program, to limit the time and work effort demand on the overwinterers.

Nevertheless, valuable information on the biomass production and resource utilization will add to the data collected during the first operations phase.

Additionally, the second operations phase will provide new information regarding remote operations of the EDEN ISS facility, in particular with respect to developing and testing operational procedures for (minimally) trained, non-expert, on-site operators.

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).

References

Beisel N, et al. (2018) Utilization of single-image normalized difference vegetation index (SI-NDVI) for early plant stress detection. Applications in Plant Sciences 6(10): e1186.

Boscheri G, et al. (2016) The EDEN ISS Rack-like Plant Growth Facility. 46th International Conference on Environmental Systems.

Vrakking V, et al. (2017) Service Section Design of the EDEN ISS Project. 47th International Conference on Environmental Systems.

Zabel P, et al. (2015) Introducing EDEN ISS: A European project on advancing plant cultivation technologies and operations. 45th International Conference on Environmental Systems.

Zabel P, et al. (2017) Future Exploration Greenhouse Design of the EDEN ISS Project. 47th International Conference on Environmental Systems.

Zabel P, et al. (2019) Biomass Production of the EDEN ISS Space Greenhouse in Antarctica. Frontiers in Plant Science (not yet published).

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

Saeid Bagheri-Dastgerdi, Melanie Behrens (not in field), Maria Hörhold (not in field), Martin Werner (not in field) — AWI

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 were 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, the isotopic composition of water vapour can be measured 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, are conducted. During the field season of ANT-Land 2018/19 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 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 preliminary analyses results, which have been presented by S. Bagheri at the EGU 2019 conference in Vienna (Bagheri Dastgerdi et al., 2019), reveal the following:

As expected, the isotopic composition of vapour shows clear seasonal changes during the period Feb 2017 – Feb 2019 (Fig. 4.12.1), with most depleted $\delta^{18}O$ and δD values in July (austral winter) and most enriched values in February (austral summer). $\delta^{18}O$ and δD are very well correlated with each other (r=0.99), and they also show a high correlation with temperature (r=0.86) and also with humidity (r=0.82). The slope of the relation between $\delta^{18}O$ in vapour and temperature is 0.55 ‰/°C, which is substantially lower than the slope between $\delta^{18}O$ in Antarctic snow and temperature (0.79 ‰/°C; Werner et al., 2018). Additional analyses are necessary to explain key processes that control these different slopes. ECHAM5-wiso model results will be very helpful for such analyses as the ECHAM5-wiso model correctly captures the seasonal and synoptic variability of $\delta^{18}O$ and δD in vapour at *Neumayer Station III* with a high correlation between model results and observational data (r=0.75).

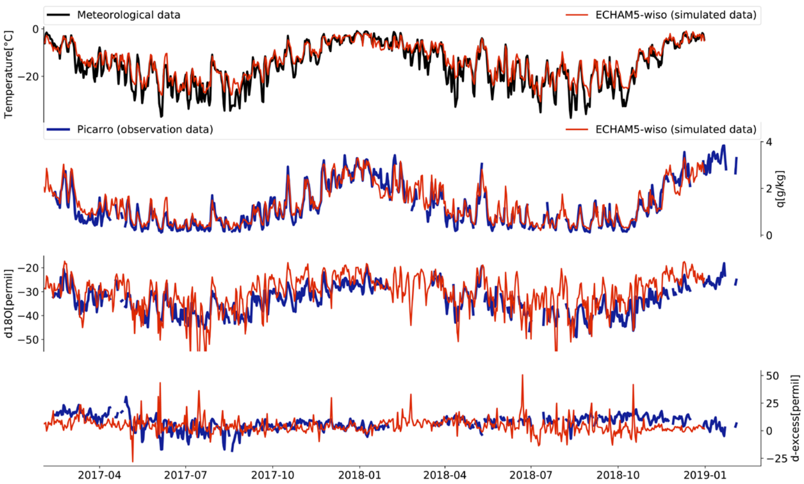

Fig. 4.12.1: Comparison of observations (black, blue) and simulated data (red) at the Neumayer Station III in Antarctica (2017-02 – 2019-02). From top to bottom: temperature (metrological data & modelled values), humidity, $\delta^{18}O$, and d-excess.

In a next step, moisture sources of the vapour at *Neumayer Station III* have been estimated for the observation period based on air masses dispersion simulations with the FLEXPART model. Most of the moisture is transported to the station by cyclonic circulation patterns, with significant seasonal variations: The dominant water vapour source stems from the north-west in spring, from the east in fall and from the west in winter (Fig 4.12.2). Contrary to the other seasons, a high local moisture uptake in the coastal areas close to the station is observed in summer. This local moisture source is certainly related to open water conditions in the *Atka Bay* in the summer season. Its influence on the isotopic signature of the vapour at *Neumayer Station III* will be investigated in further analyses.

Data management

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

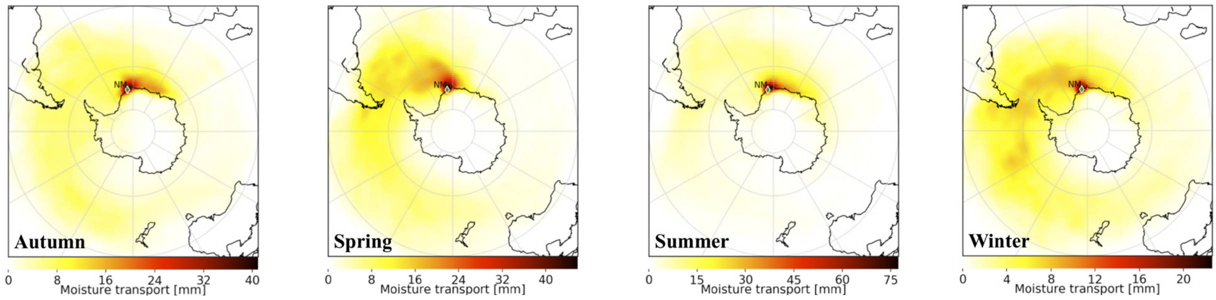

Fig. 4.12.2: Simulated seasonal moisture transport towards Neumayer Station III, as simulated by the FLEXPART model

References

Bagheri Dastgerdi S, Werner M, Bonne J-L, Behrens M, Hörhold M & Lohmann G (2019) Continuous monitoring of surface water vapor isotopic composition at Neumayer-III Station, East Antarctica. EGU General Assembly 2019, Vienna, poster EGU2019-2419.

Werner M, Jouzel J, Masson-Delmotte V & Lohmann G (2018) Reconciling glacial Antarctic water stable isotopes with ice sheet topography and the isotopic paleothermometer. Nature Communications, 9(1), 3537, https://doi.org/10.1038/s41467-018-05430-y.

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

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Outline

Set up a second worldwide Emperor Penguin Life Observatory: long-term monitoring of the emperor penguin colony of 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.

Objectives

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 ca. 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, considering in addition that the species is at a high risk of extinction in a very near future according to climatic scenarii. In that context, this second worldwide Life Observatory of emperor penguins (started in 2017 in Atka Bay) aims to predict the species' adaptive potential to climate change and associated fluctuations in prey abundance and distribution.

Life-long monitoring of the birds is performed using Radio-Frequency Identification (RFID) methodology: each year and over several decades, emperor penguin fledging chicks from the colony of Atka Bay are marked with small Passive Integrated Transponders (PIT) in order to monitor birds of known-age and -history throughout their life.

Moreover, as umbrella species, seabirds can play an important role in determining the size for conservation areas. Thus, gathering knowledge on the distribution at sea of the species will help 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, 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.

The proximity of the *Neumayer Station III* to the Atka Bay emperor penguin colony represents a tremendous opportunity to fill this gap. Moreover, the characteristics of both Pointe Géologie 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 the species, and its adaptive potentialities while facing environmental changes.

Fieldwork

The ANT-Land 2018/19 summer season for MARE Program ran from 02 November 2018 to 11 January 2019.

From 05 November 2018 to 10 January 2019, 300 five-months-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. 4.13.1).

Fig. 4.13.1: Two micro-tagged emperor penguin fledging chicks (still with faint green paint spot on their down) leaving Atka Bay colony for their first sojourn of several years at sea

From 05 November 2018 to 06 December 2018, 20 emperor penguin breeding adults had been equipped with GPS-TDR-VHF data-loggers. After identifying an adult feeding its chick at the peripheral of the colony, we isolated the duo out the colony, in a corral. Chick was handled as previously described, and adults were measured (flippers and beak), blood and feather sampled, marked subcutaneously with a PIT-tag, externally equipped with GPS-TDR-

Fig. 4.13.2: a) Emperor penguin breeding adult equipped with GPS-TDR-VHF data-loggers using Tesa-tapes and Colson-ties, and b) weighted (e.g. 30 kg)

VHF data-loggers using Tesa-tapes and Colson-ties, weighted, and temporary marked before release (for identifying the bird for the recapture/retrieval of the equipment) (Fig. 4.13.2). Then, visual observations and checks with VHF-antennas were performed every *ca.* 4 to 6 hours throughout the 24h-day over the all season to recover the equipped birds and the material (Fig. 4.13.3). We were able to recover 16 GPS-TDR-VHF devices. We were also able to recapture and recover the devices of 4 over the 8 post-moulted emperor penguin adults which were equipped with ARGOS-TDR data-loggers last January 2018. Our arrival at the field site very early in the season and the installation of a shelter closer to the colony (Fig. 4.13.4) were the keys of the success of our deployment goal this season.

Fig. 4.13.3 VHF radio-tracking check every 4-6 hours during the entire season to recover the breeding adult equipped with GPS-TDR-VHF data-loggers. The emperor penguin colony of Atka Bay in the background.

Fig. 4.13.4: Shelter on the shelf ice installed at the old location of SPOT, at 500 m of the sea-ice ramp

Due to a premature departure from *Neumayer Station III* (on 11 in the morning instead of 16 January 2019), no post-moulted adults were ready for ARGOS-TDR deployments as initially planned for this season. A few individuals were almost ready for the deployment (a couple of days would have been sufficient), but their new feathers were still not completely grown - still a few mm to grow - and thus fragile, therefore we preferred not to deploy the data-loggers on these birds, and we made the decision to deploy the devices on fledging post-moulted chicks which was initially planned for coming seasons. On 09 January 2019, 8 devices post-moulted fledglings, leaving the colony in groups to reach the sea, were captured and equipped with data-loggers (Fig. 4.13.5).

Colony census (direct and temporal population estimations through SPOT panorama), and classical phenological/breeding parameters, chick mortality, and major constraints were monitored over the course of the season. Within the framework of MARGEO/MARE projects, we also collected *ca.* 20 complete samples of regurgitated material on the sea ice, as well as the stomach content from 91 dead emperor penguin chicks, and one dead female adult emperor penguin and one individual of an undetermined penguin species (small species, *Pygoscelis*?) were recovered in Atka Bay (e.g. 5 km from the colony) and in Kottas Mountains by the team from the Traverse (e.g. approx. 400 km from Atka Bay), respectively.

Finally, general maintenance was conducted on the SPOT Penguin observatory during the entire field campaign.

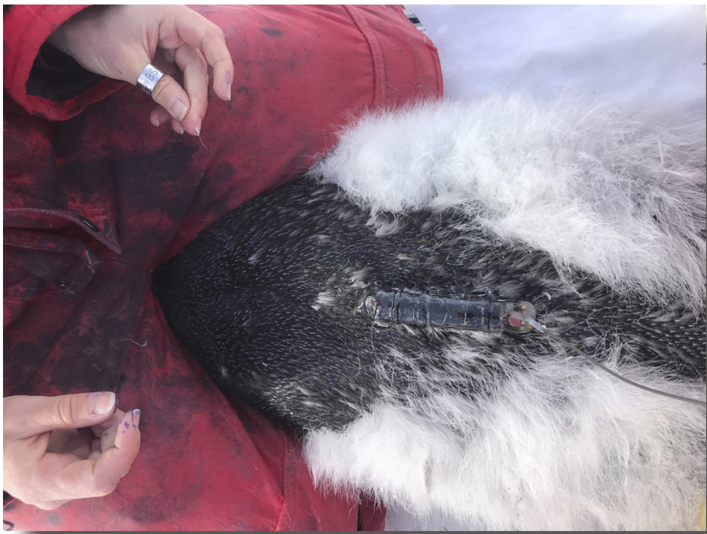


Fig. 4.13.5: Emperor penguin fledging chick equipped with Argos data-loggers using Tesa-tapes and Colson-ties

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 micro-tagging of fledging chicks and identification through mobile antennas (starting in 2019/2020), 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 in average at 5-year old).

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 (Fig. 4.13.6; Houstin et al. in prep., unpublished data).

Regarding the census of Atka Bay emperor penguin colony this season 2018/2019, an estimation of the population size was done based with SPOT panoramas taken on 09. November 2018: 7,640 adults. The estimation of SPOT panorama taken during the winter 2018 during the egg incubation by the males (i.e. half of the breeding population) gave a population size of 12,933 – 14,024 breeding pairs or ~27,000 individuals.

At this specific period of the breeding cycle (last feeding period of the chicks before they fledge - in October and November), we estimated at 18 % the percentage of adults present at the colony of Pointe Géologie, over the last years. Thus, comparing Atka Bay colony numbers with this yields to an occupancy of the colony of ~28 % instead of ~18 % at Pointe Géologie colony, hinting to a delayed breeding cycle at Atka Bay and therefore delayed phenology.

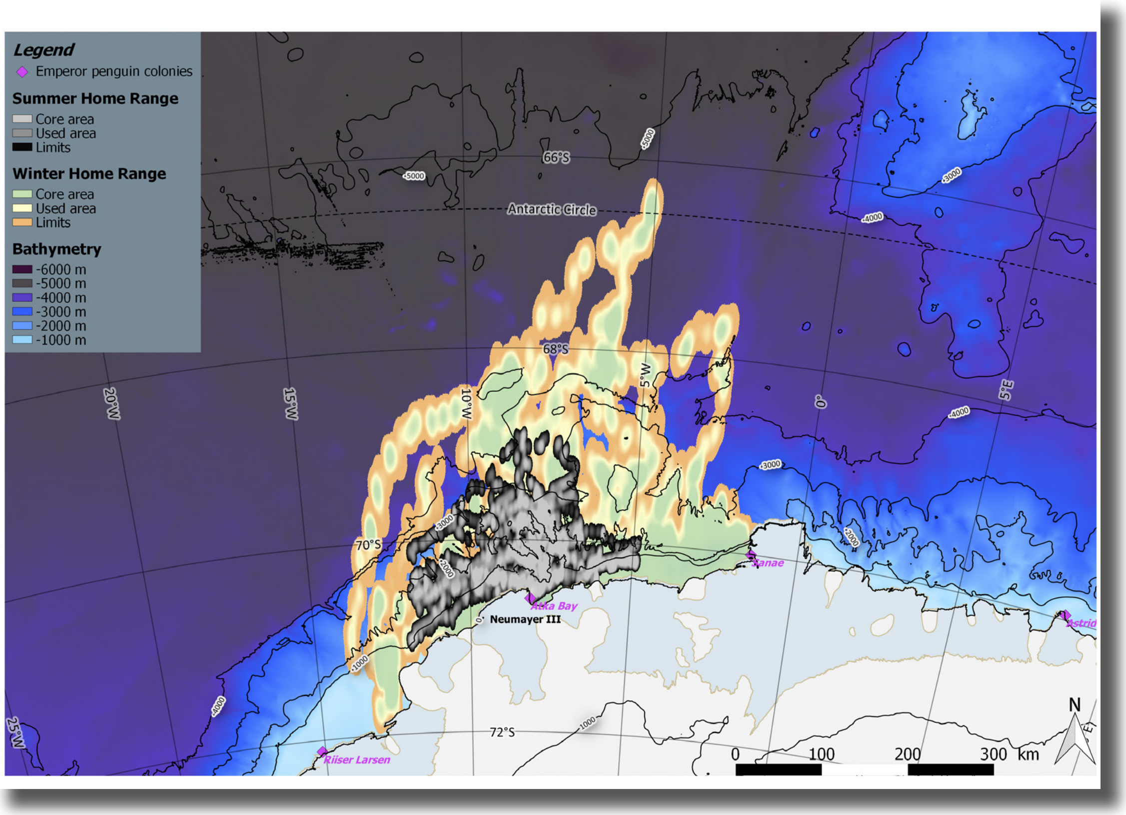


Fig. 4.13.6: Habitat use of emperor penguins from Atka Bay during the Antarctic winter of 2018 (ARGOS) and the Antarctic summers of 2017/18 and 2018/19 (GPS)

Data management

Phenology data, Capture-Mark-Recapture and 3D tracking at sea databases will be published in the World Data Center PANGAEA Data Publisher for Earth & Environmental Science (www.pangaea.de) after analyses completion of the analysis.

4.14 MARGEO – Collecting gastrolithic emperor penguin samples for geoscientific provenance and foraging analyses

Olaf Eisen[1], Céline Le Bohec[2]
Aymeric Houstin[3]

[1]AWI, [2]CNRS/CSM/IPEV
[3]CSM/U. Strasbourg

Outline

This project aims to collect gastroliths from emperor penguins (*Aptenodytes forsteri*) of the Atka Bay colony in order to 1) obtain geologic samples from the seafloor in the vicinity of the colony; 2) determine the geologic provenance and composition of gastroliths and other stomach contents to determine foraging range of Atka Bay emperor penguins; 3) perform a pilot study to consider collection of gastroliths on a continuous basis.

Objectives

We consider the following research objectives:

- Determine the geologic composition of gastroliths in Atka Bay emperor penguins. Samples are collected from guano and regurgitations on the sea ice and stomach content of dead penguin chicks. We hope that some of the gastroliths will contain geologic material stemming from the outcrop of the Explora Volcanic wedge (some 20 km south of the colony underneath the Ekström Ice Shelf), which was eroded during past advances of the ice sheet, e.g. during the Last Glacial Maximum and deposited as part of push or basal moraines (e.g. the present grounding zone at a pinning point of the Ekström Ice Shelf immediately to the south-west of the colony).
- Determine whether Atka Bay emperor penguins collect gastroliths on the sea floor in the vicinity of the colony. Apart from the few geological samples to be made available as part of the Sub-EIS-Obs project, we will compare the geologic composition of the gastroliths to that of already available marine samples obtain in the offshore region of the Dronning Maud Land coast. This will provide some indication in the foraging range of the penguins in the case that gastroliths are picked up at farther distances from the colony.

Since 2017/18, emperor penguins from Atka Bay have also been equipped with GPS (summer tracking) and ARGOS (winter tracking) devices for continuous tracking. Taking their ranges as representative for the whole colonies' foraging behaviour, it will be investigated whether the penguins could in fact serve as some sort of geological sea floor sampler.

- Compare gastroliths composition and amount between colonies at Atka Bay and Pointe Géologie (Terre Adélie), close to Dumont d'Urville French research Station. The investigations of the Atka Bay emperor penguin colony just started several years ago (e.g. with the AWI's SPOT observatory), complemented by investigations of population dynamics and ecophysiology since the 2017/18 season. In contrast, observation and collection of samples from the emperor penguin colony at Pointe Géologie have been ongoing for several decades already. Gastroliths at Pointe Géologie have been collected since 2012. The overall geographical, geological, glaciological and bathymetric characteristics at both colonies are very different. At Pointe Géologie for instance, sea floor is partly very shallow (few meter depth) including island outcrops. At Atka Bay, sea floor is up to several hundred meters below the surface, with shallow parts acting as pinning points and ice rumples for the ice shelf but still being covered by some 100 m of ice.

In addition to gastroliths, stomach samples will also provide insights into differences in the penguins' diet and foraging, for example by investigation of fresh and non-digestible food components, like squid beaks or fish eyes.

- A further question to consider is the functional role that gastroliths play for penguins. In this project, we want to make a first investigation of gastroliths to potentially lay the base for future investigations at different life-stages of the individuals (especially during the growth development of the chick) by collecting dead individuals in the colonies. That would consider the exploration of the potential roles that these gastroliths might play in this species, especially as potential aids in digestion (e.g. mechanical and chemical value, buoyancy control during foraging at sea, adaptation to fasting).

Fieldwork

Between 16 November 2018 and 10 January 2019, about 500 g of gastroliths (Fig. 4.14.1) were found on the sea ice in the vicinity of the emperor penguin colony in Atka Bay. We collected about 20 complete samples of regurgitated material as well as the stomach content from 91 dead emperor penguin chicks (Fig. 4.14.2). In addition, one dead adult penguin was recovered.

Fig. 4.14.1: Gastroliths collected by MARGEO team. Weave spacing 0.5 mm

Preliminary (expected) results

The 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. The stomach content of dead penguins showed a large variety (Fig. 4.14.2), from containing only a few gastroliths without any other material to almost 2 kg of diverse organic substances and gastroliths, including fish bones of ~10 cm length. In few cases, it appears that the chicks in fact died of overfeeding or perforation of the stomach by spiny material, i.e. fish bones ("lethal penguin adipositas"). Interestingly, comparable cases leading to death were so far not observed at Pointe Géologie.


Fig. 4.14.2: Stomach samples

It is likely that most of the regurgitated material originates rather from the penguin chicks than from adults dropping to the ground while feeding their chicks, as, most in cases, patches of material found on the sea ice were a concentrated of squid beak, fish eyes and gastroliths. In this way, the chicks potentially get rid of material (Fig. 4.14.3), which is either not digestible or too large to fit through the duodenum, which has a comparably small diameter.

Most gastroliths appeared to be of basaltic origin, some samples are potentially made up of metamorphic or sedimentary material (Fig. 4.14.1). Sizes range from a few mm, in most cases 5–10 mm, up to 4 cm across for few samples. All gastroliths appear to stem from fed material (i.e. regurgitated or stomach content), i.e. were recently collected by adults for feeding purposes. Preliminary analysis of data obtained from penguins tagged with GPS and Temperature-Depth recorders in the framework of MARE project indicates that the gastroliths originate from a maximum distance of 150 km along the coast from water depth above 450 m (maximum diving depth). Although this is a rather large range, we expect that the geologic analyses of gastroliths will extend and potentially complement the geologic material collected by sub-ice shelf sampling as part of the Sub-EIS-Obs project (see this volume), especially in view of the composition of the Explora Wedge material.

Depending on the overall results of the gastroliths and stomach content analyses, we consider to continue comparable sampling on a continuous basis in the future. Of interest are the change of the composition and size of gastroliths over the course of the feeding season (typically August to January) as well as biogenic content (e.g. change in ratio of squid to fish, type of species, etc.). Regular observations or even monitoring over several years might indicate a change in feeding behaviour with overall oceanic conditions (e.g. position of frontal systems), for instance in response to atmospheric modes (e.g. SAM, ENSO, etc.).

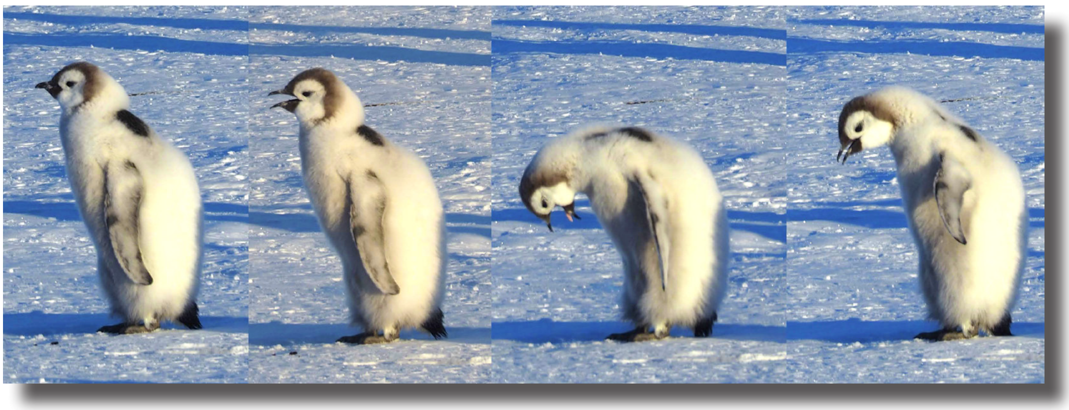


Fig. 4.14.3: Right to left: series of regurgitating chick – regurgitated material can be seen on the two left images on the snow surface

Data management

The composition of stomach content and the mineralogical composition of the gastroliths will be published in the World Data Center PANGAEA Data Publisher for Earth & Environmental Science (www.pangaea.de) after analyses will be completed.

4.15 MT_ANT2 – Magnetotelluric measurements around *Neumayer Station III*, Antarctica

Oliver Ritter[1], Tanja Fromm[2], Ute Weckmann[1]

[1]GFZ
[2]AWI

Objectives

The objectives of the project are twofold: On a longer term perspective, we would like to develop magnetotellurics (MT) as an additional geophysical deep sounding tool that can help decipher the deep hydrology and geology of Antarctica, in concert with more established and already applied geophysical methods, such as seismics, gravity, and magnetics. Electrical conductivity is an important physical parameter to identify properties of rocks and, perhaps more importantly, constituents within, such as fluids or mineralisation.

The second and more pressing objective in the short term was on overcoming technical issues with respect to the used equipment from the Geophysical Instrument Pool Potsdam, particularly with the electric field recordings.

Method

Electromagnetic (EM) methods form a discipline of geophysics, applied to study the electrical conductivity structure within Earth in a wide depth range. EM measurements depend on recordings of magnetic and electric field variations. These electromagnetic fields penetrate Earth and depending on the electric properties within, secondary fields are induced that can be measured at the Earth's surface by magnetometers and telluric electrodes.

The depth of investigation depends on the so-called skin effect, which describes that for a given conductivity (or its inverse electrical resistivity) low frequency EM fields penetrate deeper into the Earth than their higher frequency counterparts. Magnetotelluric measurements are based on naturally occurring EM field variations and can cover a frequency range from 10^{-5} to 10^{4} Hz. As MT recordings contain the lowest frequency signals, they provide the largest sounding depths of all EM methods. MT is therefore routinely used for regional scale investigations, such as plate boundaries, mountain ranges, and large fault systems.

The electrical conductivity of rocks is generally less controlled by its rock matrix but by constituents which can conduct electrical currents and as a minor effect by temperature. The bulk conductivity of a rock increases if conductive constituents form interconnected networks containing for instance brines, fluids, melts, graphite or other (metallic) mineralization.

Fieldwork

In the field season ANT-Land 2018/19, we recorded magnetotelluric data at 14 locations in the vicinity of the *Neumayer Station III* (see Fig. 4.15.1). Data acquisition lasted from 21. January 2019 until 17 February 2019 with recording times typically varying between 3 to 5 days per station; longer recording times were usually due to adverse weather conditions. Fig. 4.15.2 lists details of the recording times per station. Data recovery rate was above 90%.

For the field work, we used MT instruments provided by the Geophysical Instrument Pool Potsdam (GIPP), which were originally not designed to work under the extreme conditions of Antarctica. Problems are generally caused by the low temperatures. But the highly resistive snow at surface of Antarctica hampers the ground contact of the E-field sensors (telluric electrodes). To overcome these principal problems, we used pre-amplifiers with very high input impedances and we modified the electrolyte within the Ag/AgCl electrode container to comprise 1/3 glycerine, thereby lowering their freezing temperature to around -25°C. With this configuration we typically obtained contact resistances in the range between several hundred kOhm to a few MOhm, which remained stable for several days of recording. Figs. 4.15.3 to 4.15.5 show the deployment of an MT station in the field.

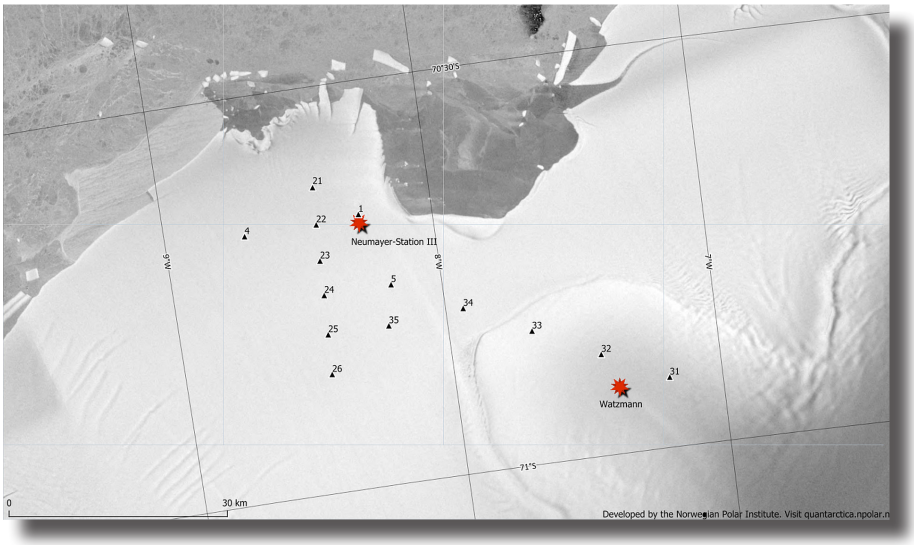


Fig. 4.15.1: Magnetotelluric station map of project MT-ANT2. The data were acquired in January/ February 2019 in the vicinity of Neumayer Station III and the seismometer station VNA2 ('Watzmann').

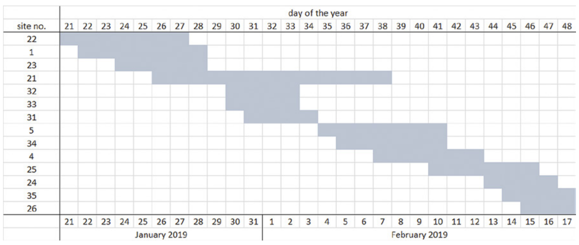


Fig. 4.15.2: Run times of MT stations of project MT-ANT2. For site locations see Fig. 4.15.1

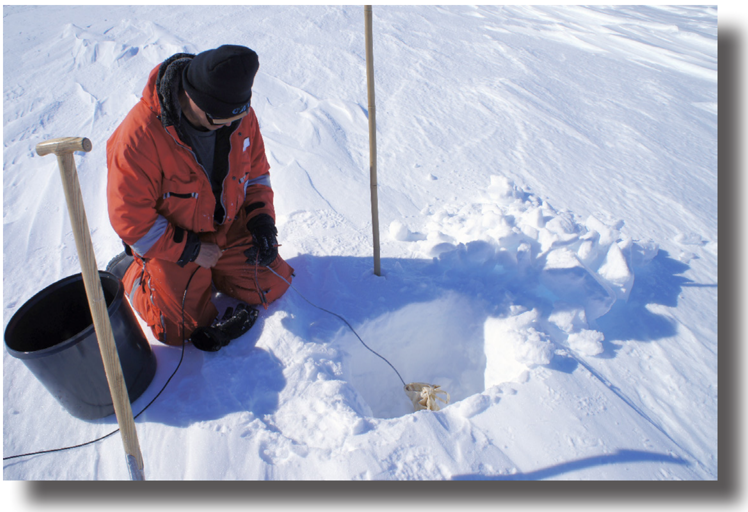


Fig. 4.15.3: Deployment of magnetotelluric station: Telluric electrodes were wrapped in cotton bags and buried in approximately 50 cm deep holes in the snow. At each station, two horizontal electric dipoles were installed in the EW and NS directions. Distance between electrodes was approximately 50 m.

Fig. 4.15.4: Deployment of magnetotelluric station: Induction coil magnetometers were buried in approximately 50 cm deep holes in the snow. Two of these induction coils were installed horizontally, another one in the vertical direction.

Fig. 4.15.5: Deployment of magnetotelluric station: After installation, the positions of sensors (electrodes and induction coils) were marked with bamboo sticks. The red box contains the data logger. Typically, after 3-5 days of recording all components were recovered and taken to the next station.

Preliminary (expected) results

Fig. 4.15.6 shows exemplary apparent resistivity and phase curves of two sites of the MT-ANT2 project. Site 21 is the northernmost station, located on the shelf ice and closest to the deep ocean. This is reflected in the sharp drop of the apparent resistivity curves, which sense the highly conductive seawater below the approximately 200 to 300 m thick ice layer. With increasing period, which is a proxy for depth, the apparent resistivity curves rise again as they are also influenced by the nearby land. Site 33 shows a completely different behaviour with apparent resistivity curves at high values, more or less over the entire period range. This behaviour can be expected as site 33 is located close to the grounding line, where the ice shelf sits above the land masses and the sandwiched conductive sea water layer is absent.

Both apparent resistivity curves show the influence of noise with scattering data points. This noise is mainly due to the above mentioned problems with the electric field recordings. Because of the high contact resistances the electric field cables act as antennas, which pick up easily internal (instrumentation) and external (*Neumayer Station III*) noise contributions.

The magnetic field data, on the other hand, is of superb quality. The so-called induction vectors are derived from the ratio of vertical to horizontal magnetic fields. They are particularly useful to map lateral conductivity contrasts. In the Wiese convention they tend to point away from the high conductivity side of such a contrast. Induction vectors vanish in the absence of a lateral conductivity contrast, e.g. above a layered or homogeneous subsurface. Fig. 4.15.7 shows that induction vectors of some sites along the so-called "Watzmann" traverse clearly map the transition from the Ekström Ice Shelf to the adjacent land masses. This result can be expected as the electrical conductivity of the highly conductive seawater represents a first order anomaly to the Archean basement rocks of the Grunehogna craton (see for example Mieth et al., 2014).

All of the results presented in this report are preliminary. Further data processing is necessary to improve the quality of the apparent resistivity and phase curves. Two- and three-dimensional modelling and inversion of the data will eventually allow us to derive true resistivity *vs*. depth sections.

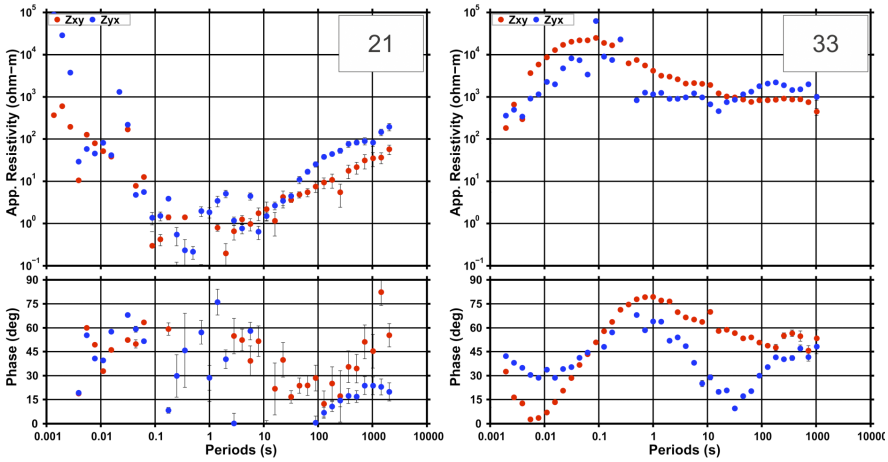


Fig. 4.15.6 :Apparent resistivity and phase curves of sites 21 (on shelf) and 33 (on grounded ice). See Fig. 4.15.1 for site locations and text for explanation

Data management

Raw data as well as a report are handed over to the Geophysical Instrument Pool Potsdam (GIPP) within a year after completion of the experiment. Data gathered with GIPP-instruments will eventually be made freely available through the "GIPP experiment- and data archive" under a Creative Common License.

References

Mieth M, Jacobs J, Ruppel A, Damaske D, Läufer A & Jokat W (2014) New detailed aeromagnetic and geological data of eastern Dronning Maud Land: Implications for refining the tectonic and structural framework of Sør Rondane, East Antarctica, Precambrian Research, Volume 245, Pages 174-185, ISSN 0301-9268.

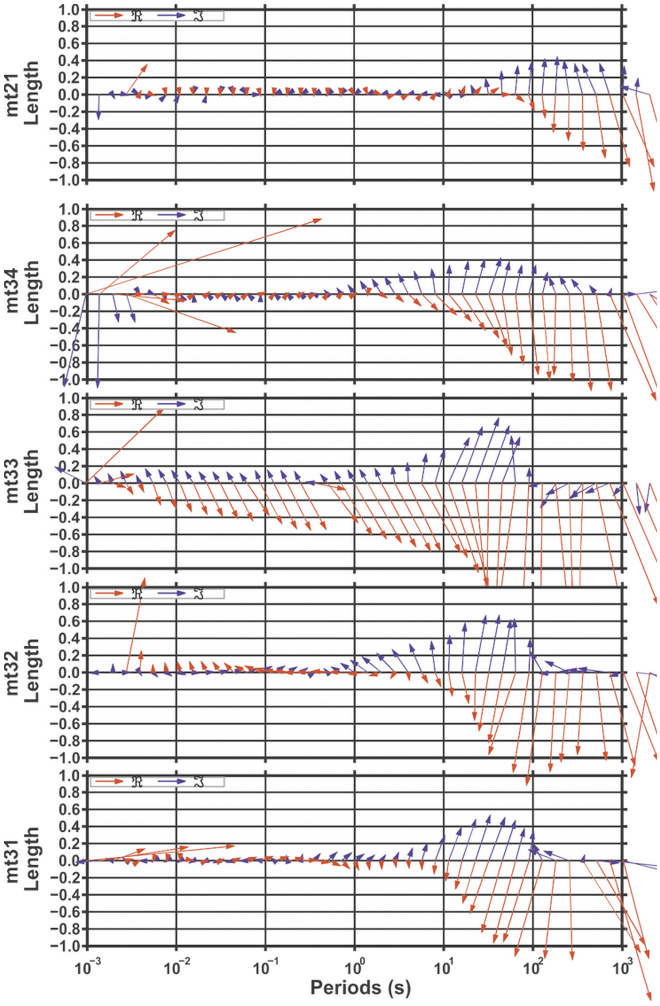


Fig. 4.15.7: Induction vectors (in the Wiese convention). Red arrows indicate the real parts, blue arrows the imaginary parts. At long periods, the induction vectors generally point southwards, away from the conductive deep ocean. The sites along the so-called "Watzmann" traverse (sites 31 to 34) indicate in addition a nearby electrical conductivity contrast with larger real induction vectors at shorter periods, with site 33 being closest to the contact. The northernmost site 21 shows a different behaviour with small (vanishing) induction vectors for most of the period range.

4.16 Mumiyo-1 – Late Quaternary environments in Dronning Maud Land inferred from Mumiyo deposits

Sonja Berg[1] (not in field), Tanja Fromm[2], Katharina Ferstl[2], Mirco Czerwonka[2]

[1]University of Cologne,
[2]AWI

Outline

The temporal and spatial distribution of snow petrel (*Pagodroma nivea*) breeding colonies in un-glaciated coastal areas but also in farther inland locations of the Antarctic continent provides important information on local (de-)glaciation histories but also on environmental conditions on land as well as in the oceanic foraging grounds of the birds (e.g. Ainley et al., 2006; Mackintosh et al., 2011; Berg et al., 2019, *in press*). Knowledge about the distribution of snow petrel colonies in the past comes from so-called mumyio deposits, which consist of fossilized stomach oil and bird guano deposited in front of snow petrel nesting cavities.

Mumiyo ages older than 50 thousand years before present (ka BP) were found in the mountain ranges of 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., 2019). 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 Utpostane 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. The samples 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 (e.g. Ainley et al., 2006).

Finally, surficial layers of mumiyo deposits will be analyzed to look for traces of human induced pollution on the Antarctic continent (e.g. for micro plastics in contemporaneous material).

The work program included prospecting for potential sampling sites and sampling of mumiyo deposits from ice-free sites in western Dronning Maud Land, including the Utpostane area in the Vestfjella and Kottas Mountains (Milorgfjella) (Fig. 4.16.1).

Fieldwork

After maintenance work was complete at the AWI-Seismometer station Utpostane (UPST) on December 13 Dr. T. Fromm, K. Ferstl and M. Czerwonka visited an unnamed nunatak c. 3 km to the north east of the seismometer station (Fig. 4.16.1). The southern slope of nunatak was accessible by foot and a total of eight samples was collected there. The sampling sites are located close to each other along a transect of 37 m.

The samples were detached from rocks witch chisel and hammer. Larger pieces were wrapped in aluminum foil, smaller pieces in sealable glasses and stored cool and in darkness afterwards. Samples were frozen upon arrival at *Neumayer Station III*, one day after sampling.

Kottas Mountains (Milorgfjella) were visited during the *Kohnen*-traverse on December 27. No snow petrels or mumiyo deposits were observed during the visit of Kottas Mountains.

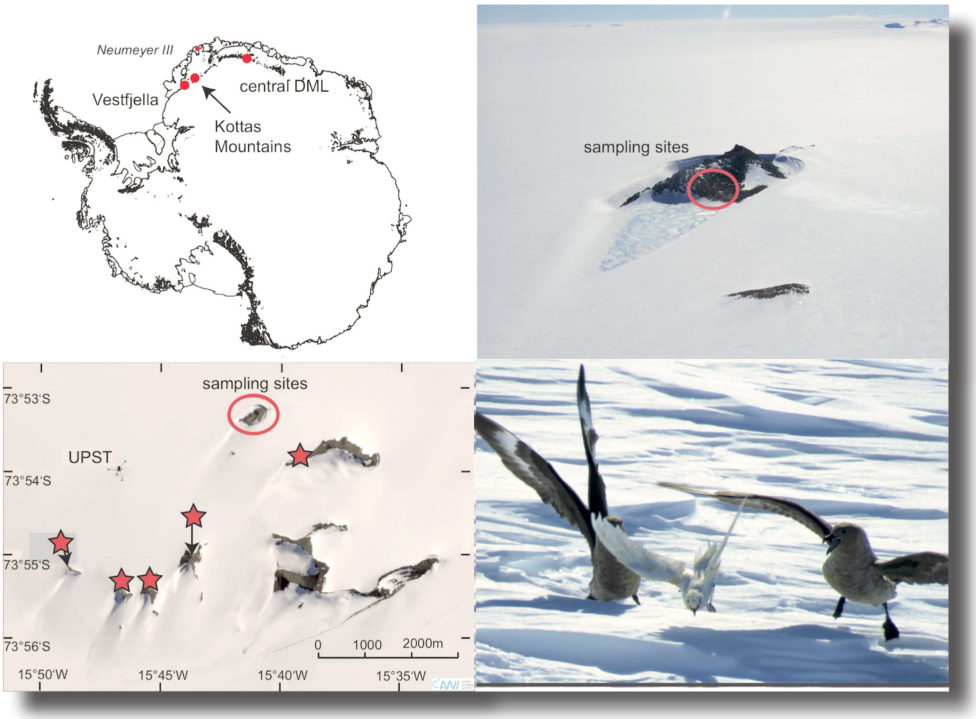


Fig. 4.16.1: Location of the sampling site in vicinity of the Utpostane (UPST) nunatak in the Vestfjella, western Dronning Maud Land (DML). Photo taken on the traverse from Utpostane to the sampling site: skuas hunting for snow petrel.

Preliminary and expected results

At the nunatak Utpostane (AWI seismometer station) no breeding snow petrels were found, but some South polar skuas (*Catharacta maccormicki*) were observed. The nunatak is likely frequently visited by skuas for feeding, which is suggested from bone remains of snow petrels that are spread over the rocks (Fig. 4.16.1). On mountains in the surroundings of the station flying snow petrels were observed via binoculars, including the nunatak that was selected for mumyio sampling.

The sampling sites are located on the lower parts of the debris-coved southern slope of the nunatak. Many active birds (snow petrels) were present and numerous cavities occupied by birds were observed. The nesting cavities are well hidden under boulders and in rock cavities and active occupation of nesting cavities was mostly only recognized from the noises of the birds when they were approached closer than a meter. Nests that were possibly occupied by breeding birds were not sampled to avoid disturbance of the animals.

Samples consist of larger mumiyo deposits (e.g. 1/1 and 1/2, Tab. 4.16.1), which were found in front of the entrance of nesting cavities. Other (e.g. 1/8 Tab. 4.16.1) are less thick and are developed as encrustations of the rocks surrounding the nests. Samples 1/4 and 1/7 were collected between debris and were not located in proximity to any nesting cavities (Fig. 4.16.2). These two deposits are likely not *in situ* and were re-located from the place of their formation. This could be due to mass movement downslope, but also result from re-working by glacial erosion, when the ice sheet was higher than at present day.

Fig. 4.16.2: Snow petrel in nesting cavity under boulder. Photos of mumiyo deposits sampled on the southern slope of the un-named nunatak. See hammer and chisel for scale in the lower image.

Tab. 4.16.1: Sampling locations and description of mumiyo samples collected on the nunatak to the south of Utpostane Nunatak.

Sample ID	Latitude	Longitude	altitude (m asl)	Description
1/1	73°53.4001' S	15°41.385'W	n.d.	massive mumiyo deposit from abandoned nest under boulder, c. 6 cm thick
1/2	73°53.407'S	15°41.390'W	n.d.	mumiyo deposit under boulder c. 10 cm thick
1/3	73°53.396'S	15°41.345'W	374	mumiyo encrusting rocks in front of abandoned nest (< 5 cm thick)
1/4	73°53.392'S	15°41.343'W	374	mumiyo deposit, likely re-worked
1/5	73°53.392'S	15°41.343'W	374	mumiyo encrusting rocks in front of active nest (< 5 cm thick)
1/6	73°53.392'S	15°41.343'W	374	mumiyo encrusting rocks in front of active nest (< 5 cm thick)
1/7	73°53.392'S	15°41.343'W	374	mumiyo deposit, likely re-worked
1/8	73°53.392'S	15°41.343'W	374	mumiyo encrusting rocks in front of active nest (< 3 cm)

Planed work on the mumiyo samples includes age determination by radiocarbon analysis to provide first constraints on the snow petrel occupation history of the area. Thick and well-stratified deposits will be further analyzed for biomarker and inorganic chemical and mineralogical composition.

Data management

Tab. 4.16.1 is also accessible in the World Data Center PANGAEA Data Publisher for Earth & Environmental Science (www.pangaea.de).

References

Ainley DG, Hobson KA, Crosta X, Rau GH, Wassenaar LI & Augustinus (2006) Holocene variation in the Antarctic coastal food web: linking δD and $\delta^{13}C$ in snow petrel diet and marine sediments. Marine Ecology Progress Series, 306, 31-40.

Berg S, Melles M, Hermichen W-D, McClymont EL, Bentley MJ, Hodgson DA & Kuhn G (2019) Evaluation of mumiyo deposits from East Antarctica as archives for the Late Quaternary environmental and climatic history. Geochemistry, Geophysics, Geosystems, 20, 260-276.

Berg S, White D, Hermichen W-D & Emmerson L (in press). Late Holocene colonisation of snow petrels (*Pagodroma nivea*) of the Prince Charles Mountains, Antarctica. Polar Biology, doi:10.1007/s00300-019-02509-0

Hiller A, Wand U, Kämpf H & Stackebrandt W (1988) Occupation of the Antarctic continent by petrels during the past 35000 years: inferences from a ^{14}C study of stomach oil deposits. Polar Biology, 9, 69-77.

Hiller A, Hermichen W-D & Wand U (1995) Radiocarbon-dated sub-fossil stomach oil deposits from petrel nesting sites; novel paleoenvironmental records from continental Antarctica. Radiocarbon, 37, 171-180.

Mackintosh A, Golledge N, Domack E, Dunbar R, Leventer A, White D, Pollard D, DeConto R, Fink D, Zwartz D, Gore D & Lavoie C (2011) Retreat of the East Antarctic ice sheet during the last glacial termination. Nature Geoscience, 4, 195-202.

Thatje S, Hillenbrand C-D, Mackensen A & Larter R (2008) Life hung by a thread: endurance of Antarctic fauna in glacial periods. Ecology, 89, 682-692.

Thor G & Low M (2011) The persistence of the snow petrel (*Pagodroma nivea*) in Dronning Maud Land (Antarctica) for over 37,000 years. Polar Biology, 34, 609- 613.

4.17 NPF Ant – Molecular steps of new particle formation at the Antarctic coast

Mikko Sipilä, Lisa Beck INAR

Objectives

The project NPF Ant focusses on quantifying the gas phase precursors leading to secondary aerosol particles and resolving the chemical composition of new particle formation at coastal Antarctica. The goal is to resolve the initial steps leading to naturally formed cloud condensation nuclei (CCN) in Antarctic area without anthropogenic influence and therefore improving the climate models regarding cloud formation in polar regions.

The most abundant precursor gases in the Arctic and Antarctic are emitted by phytoplankton. Those gases include dimethyl sulphide (DMS) and molecular iodine. Those components are further oxidized in the atmosphere and go into particle phase. As previously shown in Jokinen et al., 2018, negative ion-induced nucleation of sulfuric acid and ammonia is a major source of secondary aerosol in Antarctic atmosphere, but also iodic acid is contributing to particle formation and has potential to grow up to CCN size (Sipilä et al., 2016).

Fieldwork

In order to measure the precursor gas concentration, a Chemical Ionization Atmospheric Pressure interface Time-of-Flight (CI-APi-TOF) mass spectrometer was being used (Jokinen et al., 2012). The instrument was operated in negative ion mode with charged nitric acid (NO_3^-) and is capable of detecting sulfuric acid, methane sulphonic acid as well as iodic acid.

The molecular composition of the naturally charged ions and ion clusters leading to particle formation was measured with an APi-TOF without chemical ionization (Junninen et al., 2010) in negative ion mode. During new particle formation events, the ion mode was switched to positive for a certain time period in order to understand why the positive ions are not clustering.

For measuring the particle size distribution, a Neutral cluster and Air Ion Spectrometer (NAIS, Manninen et al., 2016) was used to obtain the size distribution of naturally charged ions with a diameter of 0.8 to 40 nm as well as the neutral particles between 2 and 40 nm. Additionally, a Particle Size Magnifier (PSM) was measuring ultrafine particles between 1 and 4 nm (Vanhanen et al., 2011).

The setup of instruments was located inside a container next to the *Air chemistry observatory (SPUSO)* about 1.5 km South of *Neumayer Station III* (Fig. 4.17.1).

The measurements started on 17 November 2018 and ended on 7 February 2019.

Preliminary results

During the measurement campaign the newly formed particles only reached sizes about 5 nm. Before the particles could grow any further, the sulfuric acid concentration mostly decreased again. In total 12 negative ion induce nucleation events out of 85 measurement days were observed. The sulfuric acid and MSA concentration has an increasing trend over the summer as expected. Yet the concentrations are not sufficiently high enough to reach a level for proper particle growth. Since the Atka Bay still was frozen throughout the measurement campaign, the phytoplankton activity could not be captured with the measurements.

Fig. 4.17.1: Measurement Container (left) and Air chemistry observatory, SPUSO (right)

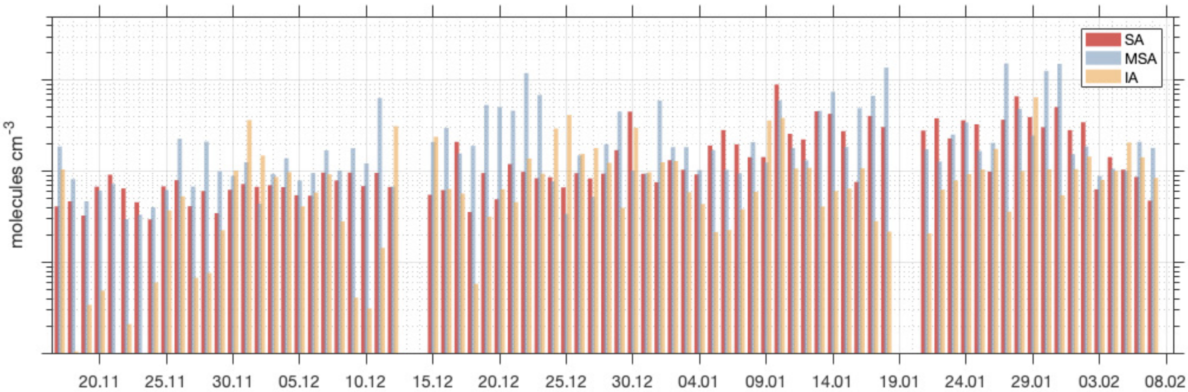


Fig. 4.17.2: Daily mean of sulfuric acid (SA), methane sulphonic acid (MSA) and iodic acid (IA) concentration. The absolute numbers still need to be confirmed after further data processing.

An example of negative ion induced nucleation is shown in Fig. 4.17.3. With an increase of sulfuric acid concentration before noon, negative ions appear and grow up to almost 5 nm while no particles are seen in the positive channel. Nevertheless, the growth stops after less than two hours with the decrease of sulfuric acid concentration.

Data management

The collected data will be made available for the scientific community. The research will be carried out in co-operation with other teams studying the atmospheric aerosol and air chemical composition at the site.

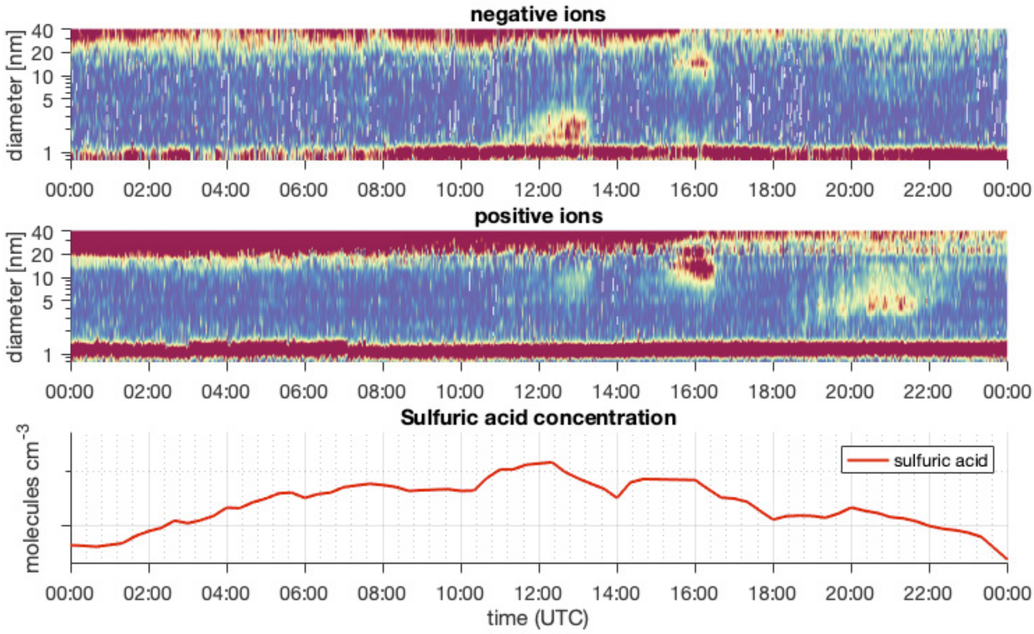


Fig. 4.17.3: Upper panel: size distribution of negative ions, middle panel: size distribution of positive ions; lower panel: sulfuric acid concentration. The day shown above is the 30 December 2018. The absolute concentrations of ions and sulfuric acid still need to be confirmed after further data processing.

References

Jokinen T, et al. (2018) Ion-induced sulfuric acid–ammonia nucleation drives particle formation in coastal Antarctica. Sci. Adv. 4, eaat9744.

Manninen H E, et al. (2016) How to reliably detect molecular clusters and nucleation mode particles with Neutral cluster and Air Ion Spectrometer (NAIS), Atmos. Meas. Tech., 9, 3577-3605.

Sipilä M, et al. (2016) Molecular-scale evidence of aerosol particle formation via sequential addition of HIO3. Nature, 537, 532–534.

Vanhanen J, et al. (2011) Particle Size Magnifier for Nano-CN Detection, Aerosol Science and Technology, 45:4, 533-542.

4.18 Sub-EIS-Obs – Seafloor sampling below the Ekström Ice Shelf

Gerhard Kuhn[1] (not in field), C. Gaedicke[2] (not in field), Raphael Gromig[1], Emma Smith[1], Ralf Tiedemann[1] (not in field), Andreas Läufer[2] (not in field), Frank Wilhelms[1] (not in field), Olaf Eisen[1], Da Gong[4,5], Li Yazhou[4], Wolf Dummann[3], Sophie Berger[1], Oliver Römpeler[1]

[1]AWI
[2]BGR
[3]Uni Köln
[4]PRIC
[5]College of Physics

Objectives

Sub-EIS-Obs is a multidisciplinary study (Kuhn & Gaedicke, 2015), which aims to recover and characterize sediment sequences beneath the Ekström Ice Shelf (EIS) in East Antarctica (Fig. 4.18.1). To investigate ocean-cryosphere-sediment interaction processes and their variability during past climate changes are the main goal of this study at the EIS. These EIS observations could be used as one example for most of the small ice shelves fed by the East Antarctic Ice Sheet (EAIS). The project is funded by AWI and BGR and addresses several research objectives, such as:

- the crustal evolution during the breakup of Gondwana (Kristoffersen et al., 2014),
- sedimentation at Antarctica's continental margin during warmer climate periods,
- the build-up and variability of the EAIS throughout the Cenozoic,
- reconstruction of grounding-line dynamics,
- sedimentary and erosional processes beneath the ice stream and shelf,
- multidisciplinary observations of climate induced changes in ice-ocean interactions,
- and the sub-shelf ice biology.

Pre-site seismic survey campaigns were carried out on the Ekström Ice Shelf in 2016/17 and 2017/18, resulting in 615 km of multi-fold seismic data (Eisen et al., 2015). Based on these data, four different depositional units were defined (Fig. 4.18.2). In order to sample all units, sediment coring locations were selected accordingly (Fig. 4.18.1). Preliminary coring took place during the 2017/18 Antarctic season with more extensive coring during the 18/19 season. Here we report on the coring operations during the 18/19 season.

Fieldwork

On-site team members were: Sophie Berger (AWI), Wolf Dummann (AWI), Olaf Eisen (AWI), Da Gong (Jilin U.), Raphael Gromig (AWI, lead sampling), Li Yazhou (Jilin U.), Oliver Römpler (AWI), Holger Schubert (Laeisz), Emma Smith (AWI, field leader).

The team was on site between 16 November 2018 and 11 January 2019 (8 weeks) with the exception of H. Schubert who arrived around 3 weeks earlier to prepare equipment. For seafloor sampling a large enough hole through the ice shelf has to be melted by hot water drilling (HWD) at the beginning.

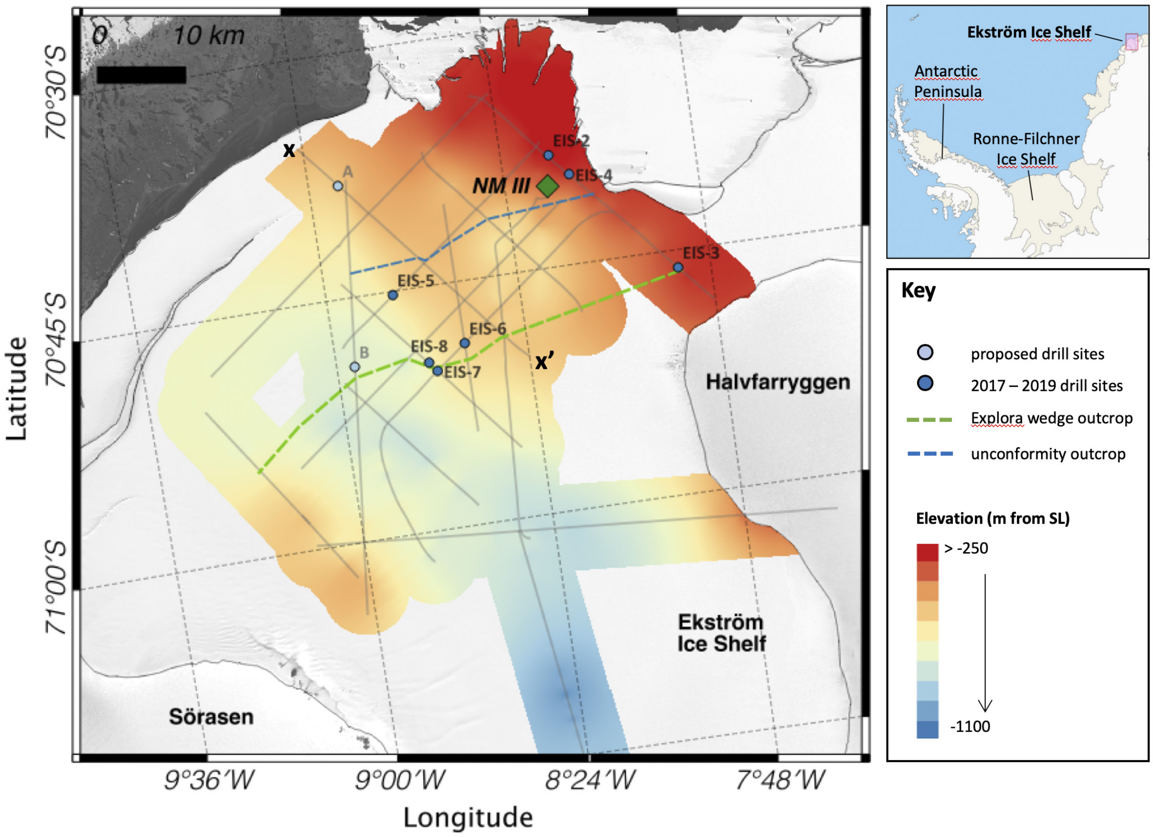


Fig. 4.18.1: Ekström Ice Shelf with key features indicated. Main map: Ekström Ice Shelf, the survey area of SUB-EIS-Obs campaign. Grey lines indicate pre-site seismic vibroseis data lines. Colored underlay is seafloor bathymetry (m below sea level) interpolated from seismic lines. Blue circles are sites where sediment cores have been take (light blue are planned core locations). The seismic line shown in Fig. 4.18.2 is indicated by X-X'. Small map: Location of Ekström Ice Shelf.

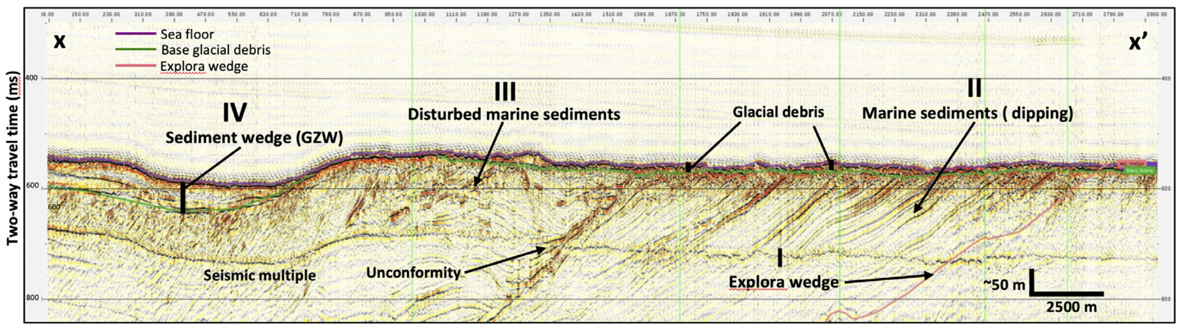


Fig. 4.18.2: Example seismic vibroseis line (X - X' in Fig. 4.14.1), image is focusing on seafloor beneath Ekström Ice Shelf (Smith et. al., 2018). The y-axis is in two-way-time, an indication of the equivalent depth is given in the bottom left corner. Key units are indicated by I-IV.

Hot Water Drilling

To access sampling locations, the AWI hot water drilling (HWD) system (Fig. 4.18.3) was used to drill holes (>30 cm in width) through the Ekström Ice Shelf, with ice thicknesses ranging between ~210 and 330 m. The system works by pumping water from a water basin through six Wap® units, which create heat (~90°C) and pressure (Fig. 4.18.3). This hot-pressurised water is then delivered both back to the water basin, to melt snow and to the drill hose via a manifold. The drill hose has an attachment on the end that delivers the water down the drill hole in a given pattern - melting the ice in front of it as it is lowered. The velocity at which the drill is lowered through the ice is controlled by a winch system and the load and depth on the winch are monitored to keep track of progress. Four different drilling attachments were used to create a hole of the required diameter, in order: Lance 1 (60 mm diameter), Lance 2 (120 mm diameter), Reamer 1 (200 mm diameter) and Reamer 2 (300 mm diameter). Each attachment must penetrate the full thickness of the ice in order to open the whole to the required diameter for equipment to be deployed.

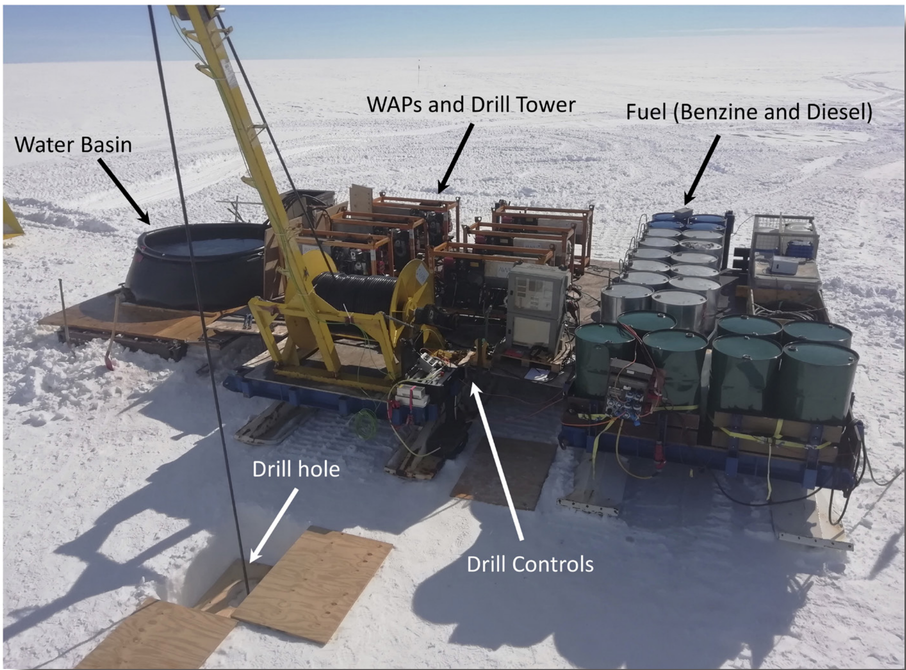


Fig. 4.18.3: AWI Hot Water Drilling system (credit: E. Smith)

In order to reduce the amount of water that must be melted form snow in the water basin, water can be re-circulated through the drill system by first drilling a shallow hole and creating a cavern under the ice, at or below the local sea level, in which a submersible pump is installed to return water to the surface. The main hole is drilled in front of the cavern hole and further away from the drill sledge by increasing the angle of the drill winch. The main hole is drilled through the cavern meaning water pumped down the main hole can then be returned to the surface to be re-heated and re-circulated. This system worked effectively in 2017/18 but less so in the 2018/19 season due to greater ice thickness at chosen drill sites (see Drilling Operations section).

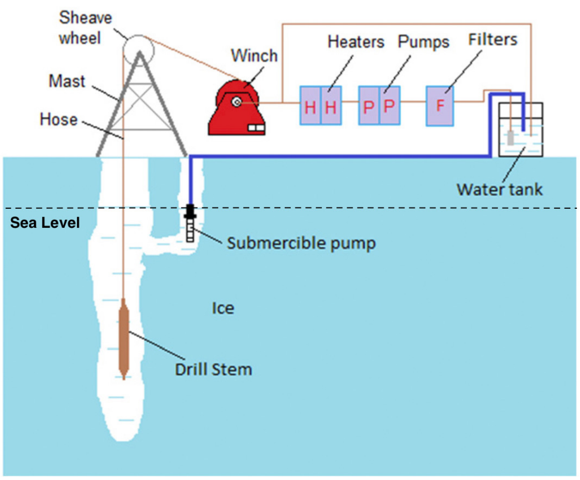


Fig. 4.18.4: Schematic of the "cavern method" of drilling (edit from Liu et. al,. 2019), a submersible pump in a shallow hole is used to return water, pumped down the main drill hole, to the surface.

Drilling Operations

In total 5 sites were drilled (EIS-4 to EIS-8) over an 8-week period. The beginning of the season was plagued by poor weather; however, the time was useful for set-up and testing of equipment and likely at least 1.5 weeks would have been needed for this regardless of weather conditions. This should be considered for future seasons, especially in the case that team members are new to the system (as was the case this season).

The general operation at each site consisted of two teams, the HWD team (4 people including the on-site coordinator) and the sampling team (5 people). The HWD team transported and set-up the HWD and living containers (kitchen and bivouac hut) and then proceed to drill the hole, working in semi-shifts with at least 2 people on shift at any given time, a third person was necessary when problems arose and during switching of drill attachments, four people were required during periods of bad weather to avoid failure of the HWD system. Progress was relayed back to the sampling team (at *Neumayer Station III*) through regular scheduled radio calls. The sampling team would arrive on site around 1 hour before the hot water drilling was finished, in order to prepare equipment, the sampling sledge (tower and winch) would be moved into place over the drill hole as soon as the HWD was clear of the hole. Sampling could then begin as the HWD was being shut down and secured for transport. The HWD team would leave the site once it was confirmed by the sampling team that the borehole was open and without problems. Progress of the sampling team would then be relayed back to the on-site coordinator at *Neumayer Station III* through regular radio calls.

There were a number of operational issues with the HWD system at EIS-4 to EIS-6, these will be discussed below. These issues led to increased drilling times at these sites. As well as that there were issues with sampling equipment at sites EIS-4 and EIS-5, which made re-reaming of the holes necessary at both sites. The cavern method (described above) was used at sites EIS-4 to EIS-6. However, due to the submersible pump being too weak to return a sufficient amount of water to the surface it was decided not to use the cavern method and simply drill by melting snow in the water basin for EIS-7 and EIS-8. This decision saved the 12-15 hours of time to create a cavern.

When the HWD is operating without issue a period of around 48 hours is needed for transport of the system to and from a drill site (with 25 km of NM) and drilling (without using the cavern method) to a depth of 330 m. During this period, the wind speed should be less than 20 kt (average) with no snowfall or drifting snow

Sampling equipment

After finishing the ice hole, the geological sampling sledge was brought into position directly over the ice hole and perpendicular to the HWD drill sledges (so sampling could begin during HWD demobilization). A 3 m tall drilling tower was mounted on the sledge, which could be folded down during transport and deployed for sampling (Fig. 4.18.5). The two deflection wheels on top of the tower were equipped with a distance meter and a load-cell. For EIS-4 and -5a 3 mm Dynatec rope was used, for following sites a 6 mm Dynatec rope with a UWITEC winch was utilized. All site meta-data, operational sampling and measuring operations are logged in Tab. 4.18.1.

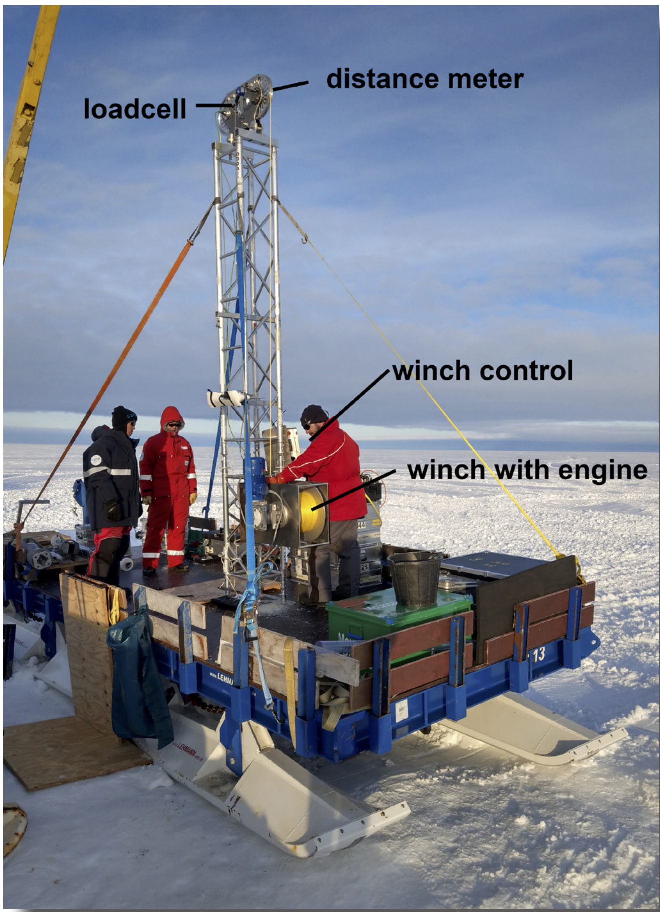


Fig. 4.18.5: General setup of the sampling sledge (after switching to UWITEC winch and control) (credit: R. Gromig).

Before any sampling instruments were deployed, the TONI device, equipped with a GoPro camera in a pressure housing (Benthic 3) and a torch (Nautilux Custom) were lowered down into the hole, lifted and the video footage immediately checked. This procedure was substantial in order to (a) check the shape and diameter of the ice-hole, (b) obtain information on sub-ice shelf currents and planktonic organisms, and (c) collect video footage of the lithological properties of the seafloor and benthic organism communities. Each of these aspects derived crucial information for the sampling procedure. Additionally, a second run with camera and torch being mounted upside down was performed in order to check the shape of the ice hole at the bottom of the ice shelf, check for organisms at the ice base, as well as the presence and texture of platelet ice.

First sampling instrument, which was deployed was the Wippermann grabber, which ideally derives a relatively high quantity sediment sample of the upper ~10 cm (Fig. 4.18.6). The grabber worked at four out of five sites, which makes it an effective instrument for sub-ice-shelf sampling.

Fig. 4.18.6: Left: TONI device with torch and GoPro camera in pressure housing. Devices are installed for filming upside down. Right: Wippermann grabber after successful deployment (credit: R. Gromig).

As a second instrument a gravity corer equipped with a 1 m plastic liner, was deployed in order to obtain an undisturbed sediment surface and a sample of the upper few decimetres below seafloor (Fig. 4.18.7). This instrument only worked at one site, due to technical insufficiencies and was shipped back for maintenance.

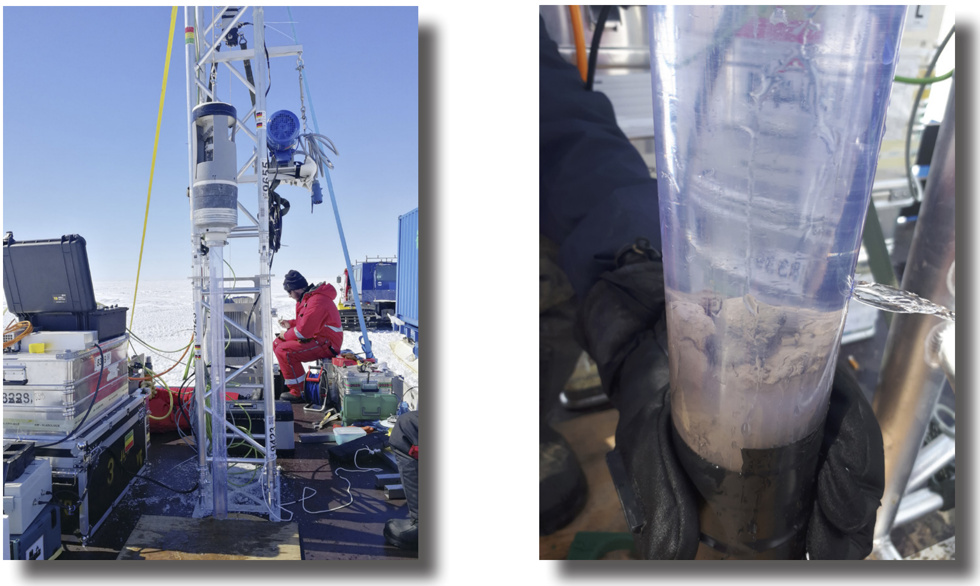
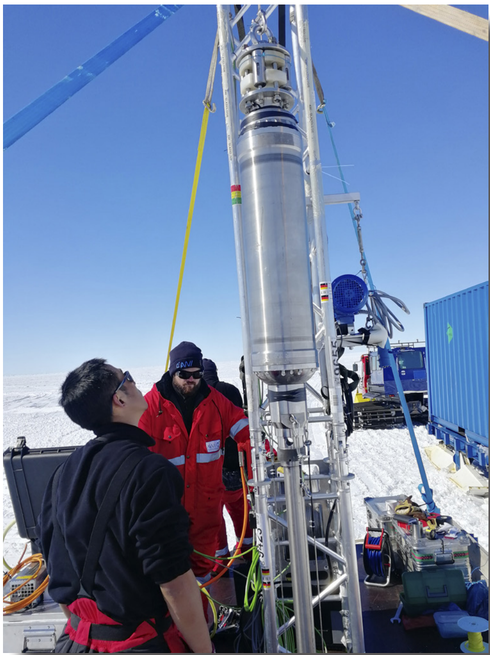


Fig. 4.18.7 Left: Gravity corer mounted with a 1 m plastic liner ready to be deployed. Right: 40 cm core sample with undisturbed sediment surface (credit: R. Gromig).

A vibro-corer (Jilin University, China), equipped with a programmable vibro-engine in a pressure housing and a 3 m steel core barrel was successfully tested without the engine first, in order to check the pressure chamber. However, first deployment of complete instrument failed, most likely because the corer first got stuck in the sediment. During the time of rescue attempts, which lasted 11 hours in total, the winch rope froze to the wall of the ice hole, which refreezes at approximately 5 mm/h at the wall. While trying to free the corer the rope eventually snapped and the instrument was lost at site EIS-5 (Fig. 4.18.8).



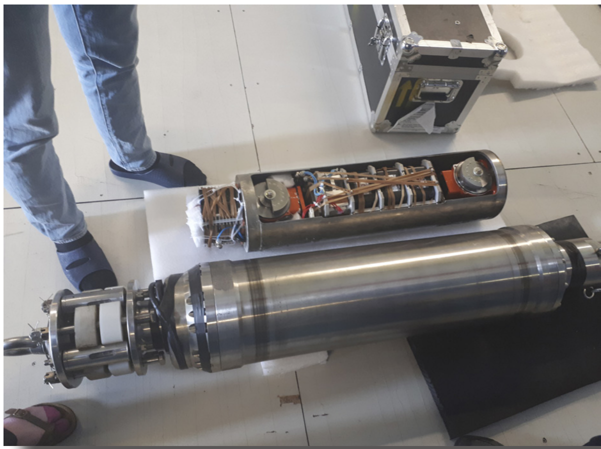


Fig. 4.18.8: Left: Vibrocorer pressure chamber (without vibro-engine) mounted with a 3 m steel core barrel. Right: pressure chamber and vibro-engine (credit: R. Gromig).

A BAS percussion corer (UWITEC, Austria) equipped with a 3 m steel core barrel with a core catcher and 80 kg hammer weights was deployed at each site except for site EIS-5 (Fig. 4.18.8). This instrument derived up to 2 m long sediment cores at sites EIS 6, 7, and 8, making it the most effective sampling device during the 2018/19 field season.

Fig. 4.18.9: Left: Percussion corer hammer-rod with four 20 kg hammer weights. Note the bent part at the bottom. Bending most likely occurred while pulling the corer out of the sediment. Right: sediment core getting cut in 1 m long pieces after extraction out of the steel core barrel (credit: R. Gromig).

The construction of an additional corer ("Jilin corer", Fig. 4.18.10) mostly from spare parts of the vibro-corer and manufactured components at NM III also derived a more than 1 m sediment core with an intact and undisturbed sediment surface.

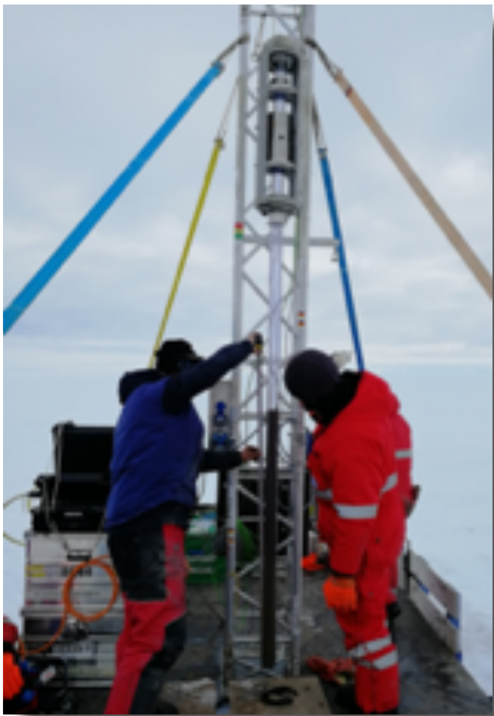


Fig. 4.18.10: Successful deployment of "Jilin-corer". Note the clear water above the sediment, indicating an undisturbed and intact sediment surface (credit: R. Gromig).

In addition to sediment sampling instruments a Conductivity-Temperature-Depth (CTD) probe was attached to the rope ca. 1 m above the grabber, gravity corer, and percussion corer. This way multiple CTD profiles could be recorded over the course of several tidal cycles. Used CTD devices were a RBR concerto and a CTD 48 M SV 6000 (Sea & Sun Technology, provided by Université Libre Brussels by J. L. Tison).

Sediment samples derived by the Wippermann grabber were directly transferred to sample bag. In case of core recovery of more than 1 m the liner was cut to 1 m pieces. Material sticking to the instruments was also collected and transferred to a separate bag. All samples were stored in a thermobox on site and shipped to Bremerhaven around 0°C.

Technical issues and recommendations

The installed load-cell as well as the distance meter were crucial instruments for the successful sampling operation. However, the required electronics (AC/DC box and winch control box) are not suitable for bad weather conditions and need to be modified accordingly. In particular, the boxes need to be waterproof and being able to work in temperatures below +5°C. The deflection wheels on top of the tower are prone to freezing, especially during ascent. A layer of ice on the wheels leads to a higher diameter of the wheel, which affects the information of the cable length on the distance meter. For future operations a Dynatec rope with a diameter of not less than 6 mm should be used in order to avoid a rope failure. It is also highly recommended to have at least one spare of key parts (core barrel, valve head, etc…) in order to stay operational in case of losing/breaking any instrument. For smooth future operations a modern designed light weight HWD is required (Makinson & Anker, 2014).

Further recommendations for sampling

We recommend taking a tide chart on-site for the duration of sampling. Over the course of a sampling period tides can alter the distance to the seafloor by more than 1 m. Also, a careful evaluation of the video footage and current meter readings should be performed in order to be aware of potentially strong currents, which can cause problems particularly when re-entering the ice-hole.

Sampling logs

The attached sampling log (Tab. 4.18.1) includes all deployments of the instruments listed above during the field season 2018/19. The list is sorted chronologically and includes times of deployment, type of gear used, core or bag samples recovered (where applicable) and remarks for each run.

Preliminary (expected) results

No analytical data are available so far. But recovering sediment cores of a total length of 10 m and several sediment surface samples from below an ice shelf are exciting successes. They are bearing invaluable geoscientific information on past and ongoing ice shelf, ocean and sediment processes. Video footages show unexpected diverse benthic communities at the seafloor below an ice shelf. A dense seafloor coverage with pebble or cobble-sized clasts provide hard ground habitats for rich benthic live at EIS-04 and EIS-07. A fine-grained muddy seafloor with soft bottom dwellers was found at EIS-5, EIS-6 and EIS-08.

An example of the CTD logging of the water column is shown in Fig. 4.18.11 from borehole EIS-5, run 5b. The device recorded during downward and upward movement, indicating consistent properties. Small differences in temperature structure can be seen around 370 m depth. Small deviations of -0.3 K from an almost linear trend towards higher water temperatures near the seafloor are present around 430 and 470 m depth. Salinity between 34.2 and 34.4 indicates Low Salinity Shelf Water (formerly Eastern Shelf Water). None of our measurements indicated a considerable layer thickness of Ice-Shelf Water.

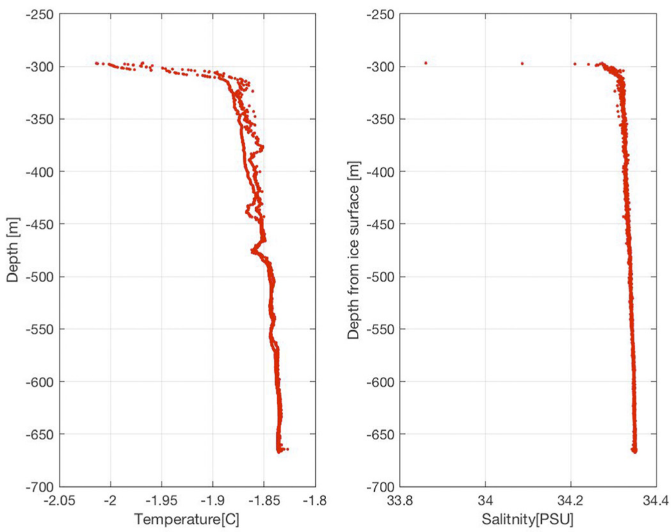


Fig. 4.18.11: Ice shelf cavity temperature and salinity CTD data from EIS-5b

Data management

Video, CTD results and further analytical data will be available in the World Data Center PANGAEA Data Publisher for Earth & Environmental Science (www.pangaea.de) latest with publication as supplement related to each publication. All datasets will be made citable including a DOI.

References

Eisen O, Hofstede C, Diez A, Kristoffersen Y, Lambrecht A, Mayer C, Blenkner R & Hilmarsson S (2015) On-ice vibroseis and snowstreamer systems for geoscientific research. Polar Science, 9, 51-65, https://dx.doi.org/10.1016/j.polar.2014.10.003.

Kristoffersen Y, Hofstede C, Diez A, Blenkner R, Lambrecht A, Mayer C & Eisen O (2014) Reassembling Gondwana: A new high quality constraint from vibroseis exploration of the sub-ice shelf geology of the East Antarctic continental margin, J. Geophys. Res. Solid Earth, 119, 9171–9182, https://dx.doi.org/10.1002/2014JB011479.

Kuhn G & Gaedicke C (2015) A plan for interdisciplinary process-studies and geoscientific observations beneath the Ekstroem Ice Shelf (Sub-EIS-Obs). Polarforschung, 84, 99-102, https://epic.awi.de/id/eprint/38587/1/Polarforschung_84-2_99-102.pdf.

Liu G, Talalay P, Wang R, Yang Y, Hong J, Gong D, Liu A & Fan D (2019) Design Parameters of Hot-Water Drilling Systems, Water, 11, No. 2 (289), https://dx.doi.org/10.3390/w11020289.

Makinson K & Anker PG (2014) The BAS ice-shelf hot-water drill: design, methods and tools. Annals of Glaciology, 55(68), 44-5, https://dx.doi.org/10.3189/2014AoG68A030.

Smith EC, Drews R, Ehlers T, Franke D, Gaedicke C, Hofstede C, Kuhn G, Lambrecht A, Mayer C, Tiedemann R & Eisen O (2018) On-ice vibroseis: What lies beneath Ekström Ice Shelf, East Antarctica? Geophysical Research Abstracts, Vol. 20, EGU2018-19374, EGU General Assembly 2018, https://meetingorganizer.copernicus.org/EGU2018/EGU2018-19374.pdf.

Tab. 4.18.1 Detailed sampling log (digital version in: https://doi.pangaea.de/10.1594/PANGAEA.905409)

Table 1: Sub-EIS-Obs Expedition Antarctica Neumayer Station Dec to Jan 2017/18

Site/Core ID	Location	Start time of run (yyyy-mm-dd-hh:mm) UTC	Time at ground (yyyy-mm-dd-hh:mm) UTC	Time on deck (yyyy-mm-dd-hh:mm) UTC	Target Category	Seismic profile ID	N (DecDeg)	E (DecDeg)	Gear	Core Length _cm	Ice Shelf Thickness_m	Meter above sea level_m	cable lenght from surface to sea floor_m	Sediment core segments	bag samples	Comment
EIS-4a	Antarctica Ekström Ice Shelf 3.4 km E from Neumayer III	2018-12-02-23:5	-	2018-12-03-18:3	III	20170553	-70.6577	-8.1969	Camera, CTDs, Grabber	-	214	36	329	-		Wippermann Grabber was combined with GoPro camera and two CTDs. Units got stuck near the bottom of the ice hole while lowering at ca. 200 m. Load dramatically increased when trying to pull up. Hammering the sampling equipment failed. Separate rope with hammer-weight attached was lowered into the hole to test if it can penetrate deeper. Weight landed on camera rig. HWD team had to come out and redo the hole. Equipment was brought back on surface by 18:30.
EIS-4b	Antarctica Ekström Ice Shelf 3.4 km E from Neumayer III	2018-12-04-5:15	2018-12-04-6:00	2018-12-04-6:30	III	20170553	-70.6577	-8.1969	Weight, CTD	-	214	36	329	-		Hammer-weight from Uwitec Percussion corer was used to check if the redrilled ice hole is open all the way. CTD was attached above the weight. No problems with.
EIS-4c	Antarctica Ekström Ice Shelf 3.4 km E from Neumayer III	2018-12-04-6:40	2018-12-04-7:20	2018-12-04-7:45	III	20170553	-70.6577	-8.1969	GoPro	-	214	36	329	-		Problems with the torch, fixed on site
EIS-4d	Antarctica Ekström Ice Shelf 3.4 km E from Neumayer III	2018-12-04-7:50	2018-12-04-8:10	2018-12-04-8:30	III	20170553	-70.6577	-8.1969	Grabber	2	214	36	329		1 bag	Lowermost 2 m operated by hand. Good surface sample quality, mostly bryozoa and sponges
EIS-4e	Antarctica Ekström Ice Shelf 3.4 km E from Neumayer III	2018-12-04-8:40	2018-12-04-8:55	2018-12-04-9:10	III	20170553	-70.6577	-8.1969	GoPro	-	214	36	329	-		GoPro rig was installed upside down in order to film the lower surface of the shelf ice, particularly the hole
EIS-4f	Antarctica Ekström Ice Shelf 3.4 km E from Neumayer III	2018-12-04-9:25	2018-12-04-10:0	2018-12-04-10:3	III	20170553	-70.6577	-8.1969	Gravity Corer	-	214	36	329	-		Last 3 m operateded by hand, penetration seemed to be good. Corer did not release and sample got lost on the way up.
EIS-4g	Antarctica Ekström Ice Shelf 3.4 km E from Neumayer III	2018-12-04-10:4	2018-12-04-11:1	2018-12-04-11:4	III	20170553	-70.6577	-8.1969	Gravity Corer	-	214	36	329	-		Last 3 m operateded by hand, penetration seemed to be good. Corer did not release and sample got lost on the way up.
EIS-4h	Antarctica Ekström Ice Shelf 3.4 km E from Neumayer III	2018-12-04-12:4	2018-12-04-13:3	2018-12-04-14:4	III	20170553	-70.6577	-8.1969	Vibro Corer	-	214	36	329	-	1 bag with single particles stuck in the core-catcher	Vibro Corer was tested without vibro-engine installed in order to make sure that the divice is water proof. Corer not upright when touching sediment surface and most likely tilted.
EIS-4i	Antarctica Ekström Ice Shelf 3.4 km E from Neumayer III	2018-12-04-15:5	2018-12-04-16:3	2018-12-04-19:1	III	20170553	-70.6577	-8.1969	UWITEC percussion	-	214	36	329	-	1 bag with single particles stuck in the core-catcher	Penetration of ca. 1 m into the sediment but then penetration decreased. Ca. 200 sledges without any further penetration. Corer got stuck at the ice hole on the way up. After ca. 40 minutes we managed to hammer the corer in the ice hole. Single sand grains at core-catcher imply that sediment was flowing out while lifting the corer. Since risk of losing a corer is too high no further coring devices will be deployed in this hole.
EIS-4j	Antarctica Ekström Ice Shelf 3.4 km E from Neumayer III	2018-12-04-20:0	2018-12-04-20:3	2018-12-04-21:0	III	20170553	-70.6577	-8.1969	Weight	-	214	36	329	-		Weight was lowered to the ground in order to test if hole is still open.
EIS-5a	Antarctica Ekström Ice Shelf 21 km SW from Neumayer III	2018-12-09-15:2	2018-12-09-16:0	2018-12-09-16:3	II	20170557	-70.7525	-8.7866	GoPro	-	293	46	673	-		Device touched icehole at 168 m below ice shelf surface while lowering, no problems when pulling it up later. Footage shows fine grained sediments with only few biogenic components and clasts.
EIS-5b	Antarctica Ekström Ice Shelf 21 km SW from Neumayer III	2018-12-09-16:5	2018-12-09-17:1	2018-12-09-17:4	II	20170557	-70.7525	-8.7866	Grabber + CTD	-	293	46	673	-	1 bag	Grabber hit ice at 173, 176, 179, and 230 m below ice shelf surface while lowering, no problems while lifting it up again. Grabber sampled sediments, which were mostly washed out on the way to the surface. Remaining sediment was transferred to plastic bag.
EIS-5c	Antarctica Ekström Ice Shelf 21 km SW from Neumayer III	2018-12-09-18:2	2018-12-09-20:0	2018-12-10-08:1	II	20170557	-70.7525	-8.7866	Vibrocorer	-	293	46	673	-		Vibro Corer was lowered to 662 m below shelf ice surface, which was, according to the information we got from runs 5a and 5b, at least 5 m above the sediment surface. Vibro unit was programmed to start at 20:00. Corer penetrated ca 50 cm into the sediment and was stuck afterwards. After ca. 11 hours of trying to free the corer joint decision was made to apply full force of the winch under consideration that the rope might break, which finally happened. The rope broke ca. 80 m above sediment surface.
EIS-5d	Antarctica Ekström Ice Shelf 21 km SW from Neumayer III	2018-12-10-9:00	2018-12-10-9:10	2018-12-10-9:25	II	20170557	-70.7525	-8.7866	Weight	-	293	46	673	-		A weight of ca. 40 kg was lowered in order to check if the ice hole is still sufficiently open to lower the camera again. Rope broke when pulling the weights up in a depth of 144 m below shelf ice surface.
EIS-5e	Antarctica Ekström Ice Shelf 21 km SW from Neumayer III	2018-12-12-13:0	2018-12-12-13:0	2018-12-12-13:0	II	20170557	-70.7525	-8.7866	GoPro	-	293	46	673	-		Camera was lowered in the caverne hole in order to check why the waterpump is stuck in the hole. Camera could not get deep enough
EIS-5f	Antarctica Ekström Ice Shelf 21 km SW from Neumayer III	2018-12-12-13:1	2018-12-12-13:1	2018-12-12-13:2	II	20170557	-70.7525	-8.7866	GoPro	-	293	46	673	-		Camera was lowered in the ice hole in order to check if hole is still wide enough to continue coring operation. Camera could not be lowered sufficiently deep enough.
EIS-5g	Antarctica Ekström Ice Shelf 21 km SW from Neumayer III				II	20170557	-70.7525	-8.7866	GoPro	-	293	46	673	-		Camera lowered in ice hole.
EIS-5h	Antarctica Ekström Ice Shelf 21 km SW from Neumayer III	2018-12-12-16:1	2018-12-12-16:4	2018-12-12-16:5	II	20170557	-70.7525	-8.7866	GoPro	-	293	46	673	-		Camera was lowered in the ice hole in order to check if the hole is sufficiently wide enough to reream the hole and to continue sampling. Tip of the broken rope is floating in the ice hole and disappears in the ice. This means, that the vibrocorer is likely still attached at the rope, which bears a high risk for the deployment of any other coring devices.
EIS-5i	Antarctica Ekström Ice Shelf 21 km SW from Neumayer III	2018-12-12-16:5	2018-12-12-16:5	2018-12-12-17:1	II	20170557	-70.7525	-8.7866	GoPro	-	293	46	673	-		Camera lowered into caverne
EIS-6a	Antarctica Ekström Ice Shelf 20 km SSW from Neumayer III	2018-12-25-17:3	2018-12-25-18:1	2018-12-25-16:3	II	20170554	-70.8134	-8.593	GoPro		309	48	607			Camera footage of ice hole and sea-floor. Sea floor sediment mostly fine grained. No pebbles visible on footage. Starfishes and tube-building worms an sediment surface.
EIS-6b	Antarctica Ekström Ice Shelf 20 km SSW from Neumayer III	2018-12-25-19:0	2018-12-25-19:3	2018-12-25-20:0	II	20170554	-70.8134	-8.593	Gravity Corer + CTD		309	48	607		1 bag	Grabber opertated by hand from ca. 5 m above sea floor. Grabber derived full sample, mostly fine grained sediment.
EIS-6c	Antarctica Ekström Ice Shelf 20 km SSW from Neumayer III	2018-12-25-20:1	2018-12-25-20:5	2018-12-25-21:4	II	20170554	-70.8134	-8.593	Gravity Corer + CTD		309	48	607			Gravity corer mounted with a 1.3 m plastic liner. Corer hit sediment and released. Material lost during lift up of the corer.
EIS-6d	Antarctica Ekström Ice Shelf 20 km SSW from Neumayer III	2018-12-25-21:4	2018-12-25-22:2	2018-12-25-22:5	II	20170554	-70.8134	-8.593	Gravity Corer + CTD		309	48	607		2 bags (1 bag with sediment remains from liner, 1 bag single clast)	Gravity corer controlled by hand from 5 m above sea surface. Liner broken but contained sediments of the upper 40 cm of the sea floor at ist inner wall. Sediment collected as mixed sample in sample bag. Single clast of ca. 2 cm diameter stored in separat sample bag. Gravel bearing sandy mud.
EIS-6e	Antarctica Ekström Ice Shelf 20 km SSW from Neumayer III	2018-12-25-23:3	2018-12-25-23:5	2018-12-26-00:1	II	20170554	-70.8134	-8.593	GoPro		309	48	607			GoPro mounted upside down to a max depth of 315 m, i.e. approx. 6 m below base of shelf ice. Camera footage shows ice hole, connection of the hole to the cavern, base of the shelf ice and platelet ice.
EIS-6f	Antarctica Ekström Ice Shelf 20 km SSW from Neumayer III	2018-12-26-01:1	2018-12-26-01:4	2018-12-26-04:3	II	20170554	-70.8134	-8.593	UWITEC percussion	198	309	48	607	EIS-6f-I = 0-98 cm + 1cm Moosi at top; EIS-6f-II = 98-198 cm	2 bags (1 bag containing core catcher, 1 bag with material scratched from core barrel)	Penetration stopped at 2 m. Problems when lifting the core out of the sediment. Core of 198 cm was retrieved. Core-catcher material extracted and transfered into sample bag. Core-catcher contained two boulders with almost the diameter than core-catcher. Material sticking to the outer wall of core barrel also sampled in separate bag. Material mostly gravely-sandy mud.
EIS-6g	Antarctica Ekström Ice Shelf 20 km SSW from Neumayer III	2018-12-26-06:2	2018-12-26-07:0	2018-12-26-07:4	II	20170554	-70.8134	-8.593	Jilin Corer		309	48	607		1 bag	Corer penetrated ca. 80 cm into the sediment. Sediment lost on the way up. Sediment was sticking to the outer wall of the liner, which was sampled in separate sample bag.
EIS-6h	Antarctica Ekström Ice Shelf 20 km SSW from Neumayer III	2018-12-26-08:2	2018-12-26-08:5	2018-12-26-10:0	II	20170554	-70.8134	-8.593	UWITEC percussion + CTD	86	309	48	607	EIS-6h = 0-86 cm	2 bags (1 bag containing core catcher, 1 bag with material scratched from core barrel)	Corer penetrated deeper in sediment but likely lost some material when pulling the corer out of the sediment. Core-catcher did not close. Corecatcher material in sample bag. Also material scratched from the outer wall of the core barrel sampled in seperate sample bag. Gravel bearing mud, clasts up to 4 cm.
EIS-7a	Antarctica Ekström Ice Shelf 24 km SSW from Neumayer III	2018-12-29-08:4	2018-12-29-09:3	2018-12-29-10:1	I	20170554/ 20170559	-70.8362	-8.685	GoPro		332	50	698		1 bag	Camera footage of ice hole and sea-floor. Boulders of up to ca. 30 cm diameter visible at sea floor, most of which covered with sponges and bryozoa. Sediment between boulders mostly fine grained. Sediment sticking to the TONI rig sampled in sample bag.
EIS-7b	Antarctica Ekström Ice Shelf 24 km SSW from Neumayer III	2018-12-29-10:3	2018-12-29-11:0	2018-12-29-11:2	I	20170554/ 20170559	-70.8362	-8.685	Grabber + CTD		332	50	698		1 bag	Grabber opertated by hand from ca. 5 m above sea floor. Grabber was in sediment but was empty when arriving on deck. Sediment sticking to the device sampled in sample bag.
EIS-7c	Antarctica Ekström Ice Shelf 24 km SSW from Neumayer III	2018-12-29-11:4	2018-12-29-12:0	2018-12-29-12:4	I	20170554/ 20170559	-70.8362	-8.685	Gravity Corer + CTD	27	332	50	698	EIS-7c = 0-27 cm + 2 cm Moosi at Top and 5 cm Moosi at Bottom		Gravity corer controlled by hand from 5 m above sea surface. Undisturbed intact sediment surface. Liner broke at bottom. Additional liner piece wrapped around broken liner in order to stabalize and cap bottom of the sample.
EIS-7d	Antarctica Ekström Ice Shelf 24 km SSW from Neumayer III	2018-12-29-13:2	2018-12-29-14:1	2018-12-29-16:0	I	20170554/ 20170559	-70.8362	-8.685	UWITEC percussion + CTD	119	332	50	698	EIS-7d-I = 0-20 cm + 1 cm Moosi at TOP; EIS-7d-II = 20-119 cm + 1 cm Moosi at Bottom	2 bags (1 bag containing core catcher, 1 bag with material scratched from core barrel)	Very slow but steady penetration in the beginning. Then load started decreasing while hammering. Hammerrod was bended and needed to be replaced with spare part. Core catcher as well as material scratched from core barrel sampled in separate bags.
EIS-7e	Antarctica Ekström Ice Shelf 24 km SSW from Neumayer III	2018-12-29-16:5	2018-12-29-17:2	2018-12-29-17:4	I	20170554/ 20170559	-70.8362	-8.685	GoPro		332	50	698			GoPro mounted upside down to a max depth of 340. Interval between 325 and 340 m below shelf ice surface recorded in 1 m steps in order to get good footage of the ice hole in the base of the shelf ice.
EIS-7f	Antarctica Ekström Ice Shelf 24 km SSW from Neumayer III	2018-12-29-17:5	2018-12-29-18:3	2018-12-29-20:0	I	20170554/ 20170559	-70.8362	-8.685	UWITEC percussion + CTD	129	332	50	698	EIS-7f-I = 0-31 cm + 1 cm Moosi at Bottom; EIS-7f-II = 31-129 cm + 2 cm Moosi at Top	2 bags (1 bag containing core catcher, 1 bag with material scratched from core barrel)	Core penetrated > 2.5 m in to the sediment but was lost during pulling the corer out of the sediment. Core catcher did not close properly. Core catcher as well as meterial scratched from core barrel sampled in separate bags.
EIS-7g	Antarctica Ekström Ice Shelf 24 km SSW from Neumayer III	2018-12-29-20:5	2018-12-29-21:3	2018-12-29-22:1	I	20170554/ 20170559	-70.8362	-8.685	UWITEC percussion + CTD	31	332	50	698	EIS-7g = 0-31 cm		Load decreased during hammering. In order to avoid bending the spare hammer rod coring was stopped in corer was broad back up.
EIS-8a	Antarctica Ekström Ice Shelf 24 km SW from Neumayer III	2019-01-04-03:3	2019-01-04-04:1	2019-01-04-04:4	I and II	20170559	-70.8257	-8.7189	GoPro		326	50	722		1 bag	Camera footage of ice hole and sea-floor. Sea floor sediment mostly fine grained. Sediment surface shows burrow-like structures. No pebbles visible on footage. Sediment trapped in a ringnut of TONI transferred to sample bag.
EIS-8b	Antarctica Ekström Ice Shelf 24 km SW from Neumayer III	2019-01-04-04:5	2019-01-04-05:2	2019-01-04-05:5	I and II	20170559	-70.8257	-8.7189	Grabber + CTD	10	326	50	722		1 bag	Grabber opertated by hand from ca. 5 m above sea floor. Grabber derived full sample, mostly fine grained sediment. Mostly very fine grained mud, only minor occurence of very fine sand.
EIS-8c	Antarctica Ekström Ice Shelf 24 km SW from Neumayer III	2019-01-04-06:0	2019-01-04-06:3	2019-01-04-07:1	I and II	20170559	-70.8257	-8.7189	Gravity Corer + CTD		326	50	722		1 bag with sediment sticking to liner and corer	Gravity corer controlled by hand from 5 m above sea surface. Corer did not release and sediment was lost. Corer penetrated deep into the sediment as indicated by sediment sticking to the bottom of the weights. Also sediment remains on the outer wall of the liner, fine grained mud near top, sandy mud at the bottom.
EIS-8d	Antarctica Ekström Ice Shelf 24 km SW from Neumayer III	2019-01-04-07:3	2019-01-04-07:4	2019-01-04-08:0	I and II	20170559	-70.8257	-8.7189	GoPro		326	50	722			GoPro mounted upside down to a max depth of 335 m below shelf ice surface. Interval between 335 and 323 m below shelf ice surface recorded in 1 m steps in order to get good footage of the ice hole in the base of the shelf ice including platelet ice. Footage was recorded as time laps video.
EIS-8e	Antarctica Ekström Ice Shelf 24 km SW from Neumayer III	2019-01-04-08:1	2019-01-04-08:4	2019-01-04-09:1	I and II	20170559	-70.8257	-8.7189	Gravity Corer + CTD		326	50	722		1 bag with sediment sticking to corer	Gravity corer controlled by hand from 5 m above sea surface. Corer did not release and sediment was lost. Corer penetrated deep into the sediment as indicated by sediment sticking to the bottom of the weights. Sediment scratched of and transferred to sample bag.
EIS-8f	Antarctica Ekström Ice Shelf 24 km SW from Neumayer III	2019-01-04-09:3	2019-01-04-11:0	2019-01-04-13:3	I and II	20170559	-70.8257	-8.7189	UWITEC percussion + CTD	161	326	50	722	EIS-8f-I = 0-61 cm; EIS-8f-II = 61-161 cm	2 bags (1 bag containing core catcher, 1 bag with material scratched from core barrel)	Corer penetrated relatively easy into the sediment in the beginning and penetration got slower while hammering. After penetrating ca. 2.5 m into the sediment load decreased while hammering rather than increase. Problems when trying to pull out the corer. Pulling took ca. 2 hours, max. load of 1000 kg applied to rope, also hammering agains the top plate of the hammer rod has been applied. Core-catcher did not close, and sediment was likely lost. Bottom sediment very stiff and compacted dark greyish clay. Core-catcher sample in sample bag. Sediment scratched of the core barrel and transferred to sample bag (stiff clay and sandy gravely mud.
EIS-8g	Antarctica Ekström Ice Shelf 24 km SW from Neumayer III	2019-01-04-14:4	2019-01-04-15:1	2019-01-04-16:1	I and II	20170559	-70.8257	-8.7189	UWITEC percussion + CTD	95	326	50	722	EIS-8g = 0-95 cm + 4 cm Moosi at Bottom		Corer penetrated into the sediment mostly by its own weight. Hammering was not possible. Hence corer was brought up in order to check if equipment is still ok, which it was in the end.
EIS-8h	Antarctica Ekström Ice Shelf 24 km SW from Neumayer III	2019-01-04-17:2	2019-01-04-17:5	2019-01-04-19:0	I and II	20170559	-70.8257	-8.7189	Jilin Corer	128	326	50	722	EIS-8h-I = 0-97 cm + 3 cm Moosi at Top; EIS-8h-II bottom is still in corecatcher, which could not be removed		Corer penetrated into the sediment relatively easy. Surface of the core seems to be undisturbed. Core-catcher could not be removed in the field because it was glued to the liner. Bottom of section II was capped and fixed with tape. Core-catcher system also included a plastic ring, which got pushed into the sediment.
Atka-a	Antarctica Atka Bight	2019-01-08-10:2	2019-01-08-10:3	2019-01-08-10:38			-70.6248	-8.1178	CTD							
Atka-b	Antarctica Atka Bight	2019-01-08-10:5	2019-01-08-10:5	2019-01-08-10:57			-70.6248	-8.1178	GoPro + CTD							
								TOTAL RECOVERED CORE		**986 cm**					**n=23 bag samples**	

Team	
Emma Smith	On-site Coordinator (AWI Glaciologist, Seismics and drilling technician)
Holger Schube	Lead Hot Water Drilling Engineer
Oliver Römpler	Hot Water Drilling Engineer
Olaf Eisen	Porject Coordintor and hot water drilling technician
Sophie Berger	Hot water drilling technician/peripheral geophysics
Wolf Dummann	Coring scientist/Sedimentologist
Raphael Grom	Lead Coring scientist/Sedimentologist
Gong Da	Vibrocorer Engineer
Li Yazhou	Vibrocorer Engineer

4.19 Test trench for the construction of a new geomagnetic observatory near Neumayer Station III (Ballontrench 1)

Peter Köhler[1] — [1]AWI
Sverrir Hilmarsson[2] — [2]Freelance

Objectives

Northeast of the *Neumayer Station III* we tested an innovative snow-building method used in Greenland under the different Antarctic snow conditions of the coastal region (Fig.4.19.1 and Fig. 4.19.2). Due to the renewal of the station's Magnetic Observatory in a few years' time, a new subterranean snow chamber is needed and was built for testing reasons and was observed as a test building.

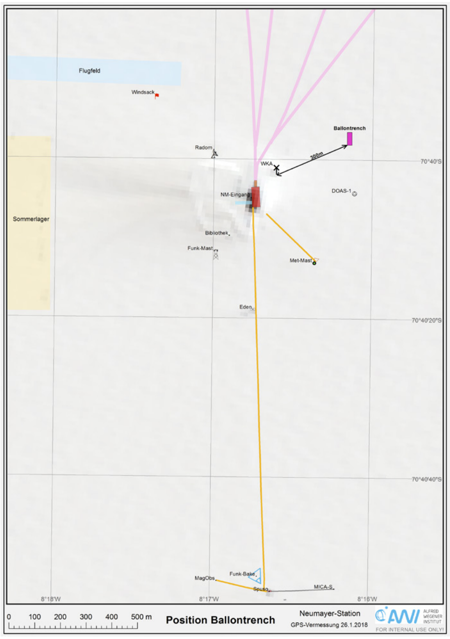


Fig. 4.19.1: Position of the Testtrenches ENE of Neumayer Station III

After completion, a 30 x 5m large cavity remains in the firn ice. In view of the annually increasing snow load on the vaulted ceiling of the cavity, the dimensional stability of the walls should be determined. For this purpose, the cavity is measured regularly and over the course of 5 years without contact by laser scanner. If the dimensional stability of the structure is given, and the room height does not decrease even with larger snow cover, a construction method is available with which large cavities can be created for logistical use or for observatories. The advantage is that after the end of use of the cavity no building material remains in the Antarctic.

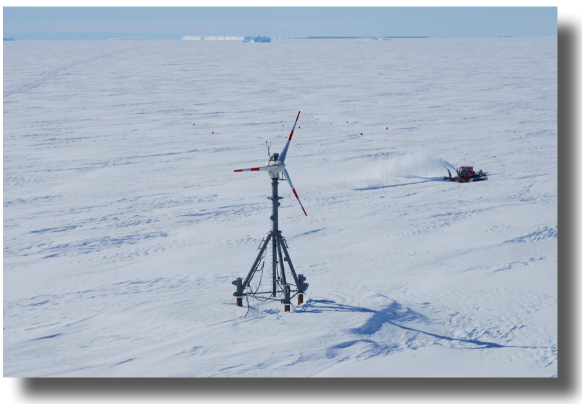


Fig. 4.19.2: construction site ENE of the Station

Fieldwork

In a snow pit (L / W / T = 34 x 9 x 8 m plus ramp) made with the snow groomer, a balloon body of dimensions Ø 30 x 5 m filled with overpressure is placed (Fig. 4.19.3). The pit is filled to the balloon with milled snow. After the milled snow has recatenated and thus formed a supporting unit, the now deflated balloon was removed. As a result a 30 x 5 m large cavity remains in the firn ice. By means of a second upright balloon of Ø 8 x 2 m, an access shaft was manufactured according to an analogous procedure. A lid component closes the access shaft snow-safe (Fig. 4.19.5).

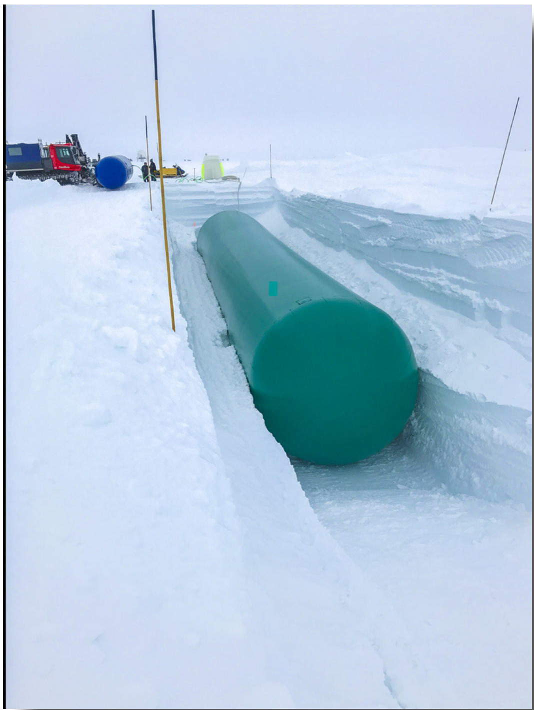


Fig. 4.19.3: Balloon placed in walls and on ground of milled snow

Preliminary (expected) results

The construction of the snow chamber was completed within the planned time with the available tools. According to a preliminary assessment, the construction process is thus also available under the prevailing snow and temperature conditions in the coastal area of the Antarctic ice shelf. After removal of the balloon body, it was found that the vaulted ceiling of the snow chamber was significantly lowered in the middle area (Fig. 4.19.4). The harmonious arch shape, which is absolutely necessary for the load absorption of coming snow layers, is not given optimally. The causes of this deviation are known and can be avoided in a successor building.

Fig. 4.19.4: Looking west to the entrance. The ceiling is designed as a vault at the top of the picture, but then drops significantly.

Fig. 4.19.5: Access of the test trench from outside

Data management

To determine the dimensional stability of the snow chamber, more than 24 measuring points allow a recurring measurement in the X, Y and Z directions. The change in length between the measuring points is considered as a factor of deformation of the inner mold. In order to gain experience with the building material condensed snow in this temperature range, besides the purely static measurement of the hall, also material analyses are carried out. For the determination of the density and for the analysis of the microstructure (structure, grain size, ...) ice cores were drawn in the area of the ceiling, the side walls and the bottom of the main chamber and in the access shaft. These cores will be examined in the ice lab at the AWI in Bremerhaven.

5. KOHNEN STATION

5.1 ASTI – Air-Snow-ice Transfer of stable water Isotopes

Maria Hörhold[1], Sonja Wahl[2], Remi Dallmayr[1], Damiano Della Lunga[1], Melanie Behrens[1], Martin Werner[1], Hans Christian Steen-Larsen[2]

[1]AWI
[2]University of Bergen

Objectives

Stable water isotopes inferred from ice cores serve as a proxy for air temperature in paleo-climate studies (EPICA 2006). They provide key elements of paleo-climate reconstructions with respect to moisture sources, global transport patterns of air masses and local air temperature at the site of precipitation. Once deposited on the ice sheet the consecutive layers store the isotopic composition while undergoing densification and diffusion and give the basis for reconstructions of paleo-temperature records (Münch et al., 2016). Recent measurements of atmospheric water vapor over the ocean (Bonne et al., 2019) and above the ice sheet as well as surface snow isotopic composition on the ice sheets (Casado et al., 2018) however question the classical interpretation of stable water isotopes as a proxy for temperature. Measurements on board of *Polarstern* reveal a strong depletion of water vapor over sea ice- covered areas, indicating a modification of the local water vapor above sublimating snow, covering the sea ice (Bonne et al., 2019). Further, observations at ice core drilling sites show, that exchange of water vapor between snow surface and the above atmosphere during periods of no precipitation significantly affects the isotopic composition of the snow (Steen-Larsen et al., 2014; Casado et al., 2018; Ritter et al., 2016). Model approaches support the finding of fractionation-induced sublimation, altering the surface snow isotopic composition in the order of seasonal changes in interior Greenland and across climate transitions in paleo-records. (Madsen et al., 2019). Amongst the processes responsible for the alteration of the isotope record in ice cores are inhomogeneous precipitation, re-distribution by the wind and air-snow interactions at the snow surface. These processes are especially important at sites with low accumulation rate, where periods of no precipitation lead the surface to be exposed to the atmosphere for a long time. To this end, the lack of understanding of exchange processes across the air-snow interface affecting the isotopic composition of the surface snow hampers the interpretation of snow and ice isotopic composition as local air temperature (Casado et al., 2018).

In connection to AWI's facilities both on *Polarstern* and at *Neumayer Station* measuring continuously the isotopic composition of water vapor, ASTI provides these measurements on the East Antarctic Plateau at *Kohnen Station* for the duration of the 2018/19 summer season. These data will complement the analysis of observations of air masses from source regions to the sink on the Antarctic ice sheet. The vapor measurements are accompanied by intensive sampling of surface snow, in line of succession with previous campaigns. Continued sampling in combination with water vapor measurements will allow to determine the influence on sublimation/condensation processes on the isotopic composition of the snow. In connection to neighbouring projects at *Kohnen Station* repetitive snow sampling of the upper 1-2 m addresses post- depositional changes of the isotope signal with depth and time.

Our specific objectives are

- To analyse the transport of air masses from the source regions to the region of precipitation and the change of isotopic composition with time, elevation and temperature: Conduct isotopic water vapor measurements at *Kohnen Station*, in parallel to measurements on *Polarstern* and at *Neumayer Station III*.
- To quantify the transfer of isotopic composition across the air-snow interface: Collect surface snow samples with high spatial and temporal coverage in parallel to water vapor measurements at Kohnen.
- To quantify the transfer of isotopic composition from the very surface snow to deeper snow layers and the effect of surface- and post-depositional processes such as sublimation-condensation: Sample snow at surface, sub-surface and together with neighbouring campaigns to 1-2 m depth, in repetition of previous campaigns.

Fieldwork

The infrastructure of the *Kohnen Station* provides good conditions for the intended investigations. The ASTI project was realised within the ANT-Land 2018/19 season. The team arrived at *Kohnen Station* on 6 December, with a delay of 8 days due to bad weather conditions. On January 23 the measurements were stopped and the equipment packed.

Continuous vapor measurements

The first days were used to set up the infrastructure for the vapor measurements, i.e. tent, power supply, tripod for sensors and tubes (Fig. 5.1). The Picarro vapor analyser was installed inside the tent (Fig. 5.1.2). First calibration measurements were conducted. Temperature, humidity and wind sensors were mounted at the tower as well as air sucking tubes on three height levels. Altogether, continuous measurements were carried out from 13 December until 23 January, while daily calibrations and maintenance were conducted.

Meteorological measurements

In order to identify local and synoptic weather patterns, several meteorological sensors were installed on the tower including an Eddy-Covariance system in order to measure surfaces fluxes directly. Those sensors were running continuously from 13 December 2018 – 23 January 2019 and maintained daily.

Snow sampling

In order to cover the expected spatial variability, a 40 m long surface transect, 150 m apart from the station to the NE (main wind direction), was set up. 20 positions were marked with a bamboo pole, 2 m apart from each other. The positions were sampled individually two times in order to determine the spatial variability over the 20 positions. Apart from that, samples were taken daily from all positions into one composite bag, “averaging” over the transect. Daily sampling of these positions was carried out in order to create a time series in parallel to the vapor measurements to track simultaneous changes in the vapor and the snow. More specifically, each position was sampled at 4 depth levels (0-0.5, 0-1, 1-3 and 3-6 cm) in order to investigate the migration of the isotope signal over time. Additionally, a 3 hour-resolution sampling was carried out over 2 days, in order to resolve a diurnal cycle in the snow.

Sample types

Surface transect composite sampling of 20 positions at 4 depth intervals from 13 December to 11 January, later samples could not be shipped

Intense sampling every 3 hours on 7 - 8 January.

Discrete sampling of all 20 positions and 4 depth intervals on 7 December and 1 January.

Overall, parallel vapor measurements and snow surface sampling were conducted for the period 13 December 2018 – 11 January 2019.

Summary

In order to investigate the impact of air-snow exchange processes on the isotopic composition of surface snow at low accumulation rate areas on the Antarctic plateau, we conducted water vapor measurements in combination with high-resolution surface snow sampling at *Kohnen Station*, Antarctica. Overall, parallel measurements of water vapor, meteorological parameters and combined snow sampling was realized for the period 13 December 2018 – 11 January 2019. Approximately 350 snow samples were collected and will be analysed and interpreted in conjunction with the vapor measurements.

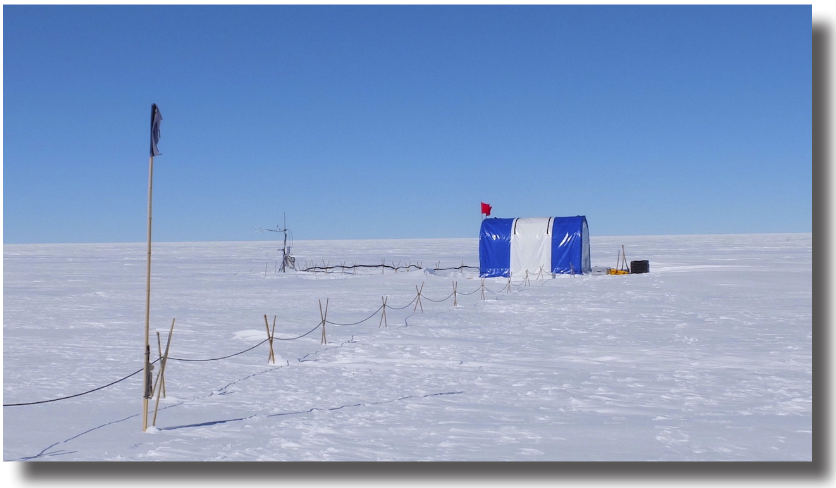


Fig. 5.1: The tent to operate the Picarro analyser. Air is sucked with a pump through insulated tubes from three height levels at the tripod into the analyzer

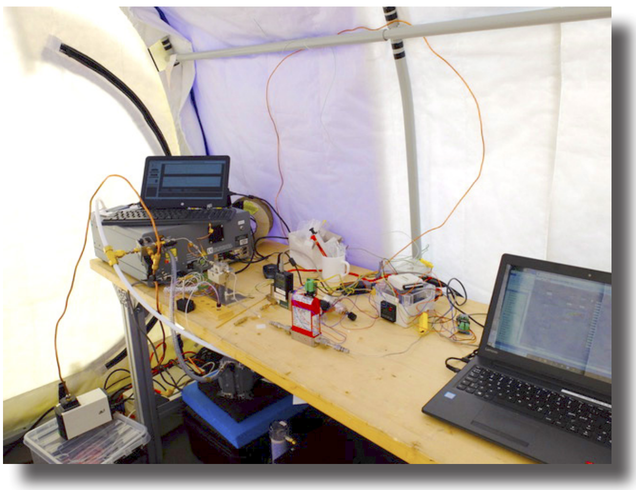


Fig. 5.2: Vapor measurement set up inside the tent

Preliminary (expected) results

- Time series of water vapor isotopic composition in combination with weather station data.
- Time series of surface and subsurface snow isotopic composition.

Data management

All data collected and generated by this project will be made publicly available via the World Data Center PANGAEA Data Publisher for Earth & Environmental Science (www.pangaea.de) after publication.

References

Bonne J-L, Behrens M, Meyer H, Kipfstuhl S, Rabe B, Schönicke L, Steen-Larsen HC & Werner M (2019) Resolving the controls of water vapour isotopes in the Atlantic sector, Nature communications, https://doi.org/10.1038/s41467-019-09242-6.

Casado M, Landais A, Picard G, Münch T, Laepple T, Stenni B, Dreossi G, Ekaykin A, Arnaud L, Genthon C, Touzeau A, Masson-Delmotte V & Jouzel J (2018) Archival of the water stable isotope signal in East Antarctic ice cores; The Cryosphere, https://doi.org/10.5194/tc-12-1745-2018.

EPICA community members (2006) One-to-one coupling of glacial climate variability in Greenland and Antarctica, Nature, 44, https://doi.org/10.1038/nature05301.

Madsen M V, Steen-Larsen H C, Hörhold M, Box J, Berben S M P, Capron E, et al. (2019) Evidence of isotopic fractionation during vapor exchange between the atmosphere and the snow surface in Greenland. Journal of Geophysical Research: Atmospheres, 124, 2932–2945. https://doi.org/10.1029/2018JD029619.

Münch T, Kipfstuhl S, Freitag J, Meyer H & Laepple T (2016) Regional climate signal vS local noise: a two-dimensional view of water isotopes in Antarctic firn at *Kohnen Station*, Dronning Maud Land; Climate of the Past, 12, https://doi.org/10.5194/cp-12-1565-2016.

Ritter F; Steen-Larsen HC, Werner M, Masson-Delmotte V, Orsi A, Behrens M, Birnbaum G, Freitag J, Risi C & Kipfstuhl S (2016) Isotopic exchange on the diurnal scale between near-surface snow and lower atmospheric water vapor at *Kohnen Station*, East Antarctica; The Cryosphere, https://doi.org/10.5194/tc-1647-2016.

Steen-Larsen HC, Masson-Delmotte V, Hirabayashi M, Winkler R, Satow K, Prie F, Bayou N, Brun E, Cuffey KM, Dahl-Jensen D, Dumont M, Guillevic M, Kipfstuhl S, Landais A, Popp , Risi C, Steffen K, Stenni B & Sveinbjörnsdottir AE (2014) What controls the isotopic composition of Greenland surface snow? Climate of the Past, 10, https://doi.org/10.5194/cp-10-377-2014.

5.2 EDML-LOG – Logging of EPICA-DML Borehole

I. Weikusat (not in field)[1], Mathias Hüther[1],
A. Frenzel (not in field)[1], F. Wilhelms (not in field)[1],
D. Dahl-Jensen (not in field)[2], D. Jansen (not in field)[1]

[1] AWI
[2]NBI Copenhagen

Objectives

Current flow properties and behaviour of ice sheets are measured with surface and remote sensing techniques, but are hardly known in the 3rd dimension with ice sheet depth. The change of the borehole shape over time can serve as a "proxy" for the flow conditions with depth.

The overall objective is thus to understand the 3D flow conditions around the former EPICA DML drill site by comprehensive combination of borehole logging results with other data sets (ice core, RES, surface, flow modelling) (e.g. Weikusat et al., 2017).

Fieldwork

Pre-requisites are repeated measurements of the borehole geometry over as many years as possible. So the central task in the field was repetition of the previous measurements (2006, 2011, 2014, 2016) with the DK-logger (UNI Copenhagen, Co-operation partner: Center of Ice and Climate, NBI, University of Copenhagen, Prof. Dr. Dorthe Dahl-Jensen) to get information about changes in the borehole properties (azimuth, inclination, diameter, temperature, pressure). Especially for the *Kohnen Station* site with its slow surface flow conditions (Wesche et al., 2007), the repeated measurements after several years are essential to optimize the signal/noise ratio. During the Season 2016/2017 the EDML-Borehole has been logged for the last time with two different borehole-loggers (operator: Andreas Frenzel). In 2018/19 these measurements have been repeated in order to refine the resolution of data in inclination, azimuth and depth, particularly in the depth of the most interesting section (approx. 2,350 to 2,390 m of depth). In this depth range bedrock-parallel simple shear deformation dominates (Weikusat et al., 2017) and huge impurity contrasts due to climate transitions (MIS 5d – MIS 5e – MIS 6) probably lead to significant rheology differences of the layers (Eichler et al., 2017, 2019).

Prior to the logger-measurements we needed to prepare the drill trench (tower & inclined trench) and maintain the winch system. The drill tower and winch was removed for future use (BE-OI) after the measurement.

To maintain the current logging capability at *Kohnen Station*, a new prototype logging winch was tested with the DK-logger in the borehole.

Preliminary (expected) results

Data sets of borehole shape from the DK-logger (azimuth, inclination, diameter, temperature) have been obtained. A first processing of the data illustrates the improved signal/noise ration (Fig. 5.2.1) as well as the changes of borehole geometry in the target depth range over the years since the EPICA DML drilling has been finalized (Fig. 5.2.2).

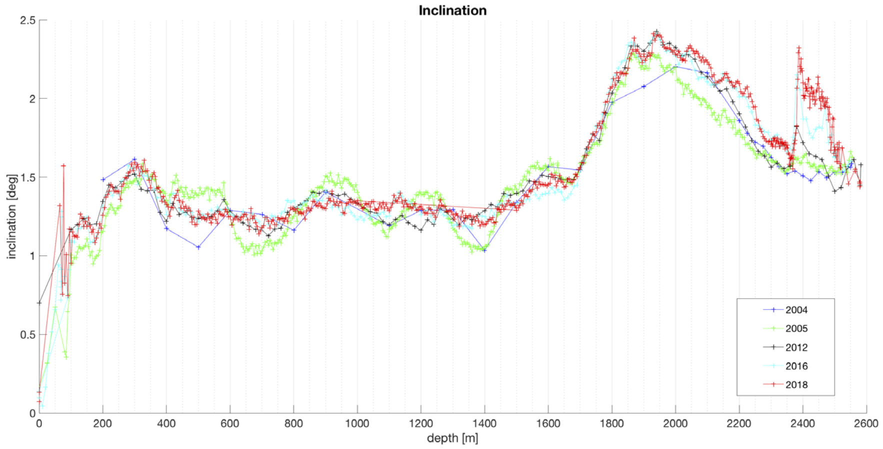


Fig. 5.2.1: Borehole inclination from the surface along the whole depth. 2018 data show a good match with previous measurements, e.g. the prominent inclination change at approx. 1,700 m of depth where the bed-parallel simple shear influence sets in (Weikusat et al., 2017). This major part of the hole length also demonstrates effective noise reduction of our vdata over the years. In the depth of the most interesting section (approx. 2,350 to 2,390 m of depth) we observe an ongoing evolution of the borehole shape as expected with the simple shear dominance. Details are shown in Fig. 5.2.2.

Fig. 5.2.2: Details of the borehole inclination in the depth of the most interesting section (approx. 2,350 to 2,390 m of depth). Despite the sub-glacial water film observed below Kohnen Station (Wilhelms et al., 2014) in this depth regime bed-parallel simple shear deformation of the ice body is clearly dominating and progressing. Further details most probably are related to the different "ice types" and their different deformability (Wilhelms et al., 2007), in this case the creep-rate controlling deformation and recrystallization mechanisms (Weikusat et al., 2009a). This includes varying impurity type and load (Eichler et al., 2019) as well as connected and thus varying evolution of microstructure and crystal-preferred orientation (Weikusat t al. 2009b).

Data management

Processing of the raw data (machine data) has been done by Prof. Dr. Dorthe Dahl-Jensen, as she is the owner and developer of the instrument. Further processing has been done by Dr. Daniela Jansen. The finalized data set will be made publicly available via the World Data Center PANGAEA Data Publisher for Earth & Environmental Science (www.pangaea.de).

References

Eichler J, Kleitz I, Bayer M, Jansen D, Kipfstuhl S, Shigeyama W, Weikusat C & Weikusat, I (2017) Location and distribution of micro-inclusions in the EDML and NEEM ice cores using optical microscopy and *in-situ* Raman spectroscopy, The Cryosphere, 11, 1075-1090.

Eichler J, Weikusat C, Wegner A, Twarloh B, Behrens M, Fischer H, Hörhold M, Jansen D, Kipfstuhl S, Ruth U, Wilhelms F & Weikusat I (2019) Impurity Analysis and Microstructure Along the Climatic Transition From MIS 6 Into 5e in the EDML Ice Core Using Cryo-Raman Microscopy, Frontiers in Earth Science, 7, 20.

Weikusat I, Jansen D, Binder T, Eichler J, Faria SH, Wilhelms F, Kipfstuhl S, Sheldon S, Miller H, Dahl-Jensen D & Kleiner T (2017) Physical analysis of an Antarctic ice core - towards an integration of micro- and macrodynamics of polar ice, Philosophical Transactions of the Royal Society of London A: Mathematical, Physical and Engineering Sciences, The Royal Society, 375, 20150347 (1-27).

Weikusat I, Kipfstuhl S, Faria SH, Azuma N & Miyamoto A (2009a) Subgrain boundaries and related microstructural features in EPICA-Dronning Maud Land (EDML) deep ice core, J. Glaciol., 55, 461-472.

Weikusat I, Kipfstuhl S, Azuma N, Faria SH, Miyamoto A & Hondoh T (Ed.) (2009b) Deformation Microstructures in an Antarctic Ice Core (EDML) and in Experimentally Deformed Artificial Ice, Physics of Ice Core Records II, Supplement Issue of Low Temperature Science, 68 (2), 115-123.

Wesche C, Eisen O, Oerter H, Schulte D & Steinhage D (2007) Surface topography and ice flow in the vicinity of the EDML deep-drilling site, Antarctica, Journal of Glaciology, 53, 442-448.

Wilhelms F, Miller H, Gerasimoff MD, Drücker C, Frenzel A, Fritzsche D, Grobe H, Hansen SB, Hilmarsson SÆ, Hoffmann G, Hörnby K, Jaeschke A, Jakobsdóttir SS, Juckschat P, Karsten A, Karsten L, Kaufmann PR, Karlin T, Kohlberg E, Kleffel G, Lambrecht A, Lambrecht A, Lawer G, Schärmeli I, Schmitt J, Sheldon SG, Takata M, Trenke M, Twarloh B, Valero-Delgado F & Wilhelms-Dick D (2014) The EPICA Dronning Maud Land deep drilling operation Annals of Glaciology, *55*, 355-366.

Wilhelms F, Sheldon SG, Hamann I, Kipfstuhl S & Kuhs WF *(Ed.)* (2007) Implications for and findings from deep ice core drillings - An example: The ultimate tensile strength of ice at high strain rates, Physics and Chemistry of Ice, Special Publications, 635-639.

5.3 FIDEMEKO - FIrn DEnsification MEasurements at Kohnen

Johannes Freitag, Holger Zahlauer, Angelika Humbert (not in field) AWI

Objectives

This project aims to measure *in-situ* firn densification rates at a cold, low-accumulation site (*Kohnen Station*) continuously over a time period of a year. This point measurement of firn densification rate at *Kohnen Station* is supposed to serve as a validation dataset for a continuum mechanical firn densification model solidFIDEMO, that is to be developed within a DFG SPP1158 proposal.

Fieldwork

In the past field season am ApRES (Autonomus phase-sensitive Radio-Echo Sounding) system has been set-up in the science trench at *Kohnen Station*. The system consists of two skeleton frame antennas, a battery and the electronic box housing receiver, transmitter and data storage. The ApRES is programmed to record one measurement per day.

Preliminary results

So far none; to derive firn densification rates a longer time series of measurements is required.

Data management

It is planned archive successfully recorded ApRES raw data in the same data repository as seismic and other radar data stored at AWI. Deduced firn densification rates will be stored in the World Data Center PANGAEA Data Publisher for Earth & Environmental Science (www.pangaea.de).

5.4 KohnenQK-1 – Quantitative reconstruction of millennial climate variability around Kohnen, Step 1, regional variability

Thomas Laepple[1], Maria Hoerhold[1], Johannes Freitag[1], Remi Dallmayr[1], Klaus Trimborn[2]

[1]AWI
[2]Logistical support

Objectives

Understanding the magnitude and causes of recent climatic trends and variability in Antarctica is hampered by a short instrumental record. Oxygen isotopes in firn and ice-cores allow to infer about past climate changes. However, the existing reconstruction efforts on the East Antarctic Plateau are too uncertain to draw quantitative conclusions about climate variability and potential anthropogenic trends (Jones et al., 2016). The limited skill of the reconstructions as well as the improved understanding of isotopic signal (Helsen et al., 2005; Karlöf et al., 2006; Laepple et al., 2016; Münch et al., 2016, Laepple et al., 2018) suggest that single firn cores or small stacks of cores are not enough to allow a quantitative climate reconstruction.

Instead, extensive arrays of firn cores, combined with a statistical separation of signal and noise are required (Münch & Laepple, 2018). In the proposed multi-season project KohnenQK, we will systematically gather the necessary information and firn core material for a quantitative reconstruction of the climate variability of the last millennium for the region around *Kohnen Station*. While our previous campaigns quantified the local isotopic variability (Münch et al., 2016), the expedition KohnenQK-1 was targeted to quantify the isotopic variability on regional (1-100 km) scales caused by spatially and temporally varying accumulation conditions.

Fig. 5.4.1: Kohnen-QK1 expedition team (left to right): Johannes Freitag, Maria Hörhold, Remi Dallmayr, Klaus Trimborn, Thomas Laepple

To this aim, systematic surface snow sampling along the ~100 km *Kohnen Station - B31* traverse was performed to quantify the relationship between isotopic composition, seasonal accumulation and surface topography (Fig. 5.4.2). The site *B31* (Oerter et al., 2004) is an ideal test case as it displays an abrupt shift in accumulation rate and isotopic composition 800 years ago that we aim to decipher and model by analyzing the surface snow at different distances. The proposed route has been extensively studied by radar (Rotschky et al., 2004; Eisen et al., 2005) showing significant variations in accumulation rate and surface topography on 5 - 100 km scales. In addition to water isotopes, the snow samples will be analyzed for impurities potentially allowing to develop detection and correction methods for changes in seasonal accumulation. KohnenQK-1, in combination with the firn cores and the knowledge gained in previous campaigns will provide an important step towards the quantitative reconstruction of the climate variability of the last millennium in the *Kohnen Station* area.

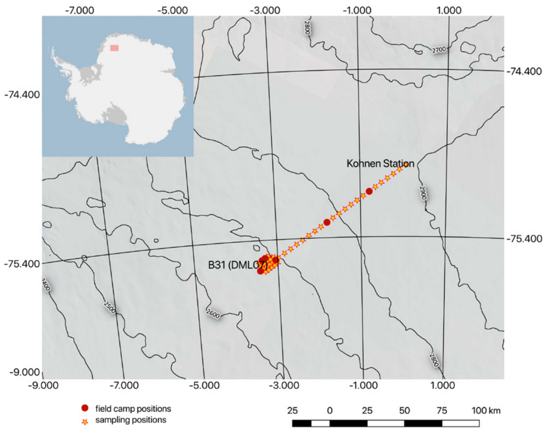


Fig. 5.4.2: Traverse route with the sampling locations (yellow stars). Red points mark the positions of the field camps

Our specific objectives are

- To quantify the relationship of local topography, accumulation conditions and spatial variations in the surface isotopic signal.
- To quantify non-climate variability in the surface isotopic variations on local (<100 m) and regional (~100 km) scales and their dependency on the depositional setting and the spatial variability of water isotopes.
- To use the results to develop a statistical model for the regional isotopic non-climate variations combining the observations and reanalysis data of precipitation and temperature that allows to correct the variability estimates (e.g. Laepple and Huybers, 2013).
- To test whether the information from impurity and isotopic variations can be combined to detect and correct for seasonal accumulation effects.

Fieldwork

Due to bad weather conditions that delayed the opening of *Kohnen Station* the traverse had to be performed in one week (10.12.2018-16.12.2018) instead of two weeks. The traverse train went to the B31 site and went along a grid North-East of the Site for few days before aiming back to *Kohnen Station* on the same line (Fig. 5.4.2). Along the traverse radar measurements were conducted. On the line as well as at the grid points, snow samples were collected, using four different methods, which are described below.

Radar measurements

Two radar antennas were mounted on sledge next to the living container of the traverse train. The antennas were operated and monitored from inside the container.

We used a 250 Mhz and a 500 Mhz Ramac antenna. The overall collected radar profiles sum up to approx. 350 km. However, due to technical issues, the 500 Mhz antenna had to be switched off most of the time. Traces were recorded by a time trigger (0.33 seconds) driving with constant velocity of 12 km/hour. Traces were recorded with 2,048 samples in a 1,000 ns time window for the 250 Mhz antenna. The traces were stored with 8 vertically stacked pulse records. Continuous geographical positioning of the records was obtained by a kinematic global positioning system (PPK), mounted at the living container.

Snow sampling

Our aim was to resolve the potential relationship between topography, accumulation and snow isotopic composition with a minimum number of samples. The sampling positions were derived prior to the campaign, based on previous radar measurements (Rotschky et al., 2004) and topographic data in order to mimize the sampling error. Along the main line from *Kohnen Station* to B31 (and back) the positions as spaced 5 km apart (Fig. 5.4.2). The grid points North-East of B31 are spaced 2.5 km apart reflecting the smaller spatial scale of the topographic structures near B31 and our requirement to sample the source region for the snow forming the B31 core. To resolve the expected isotopic changes, the small-scale stratigraphic noise (horizontal decorrelation scale <5 m) has to be reduced by spatial averaging. Based on previous results (Münch et al., 2016) we determined that we need 10x 1 m long samples with a 10m distance (90m distance) at each sample site to achieve a reasonable signal to noise ratio (SNR>3). Further, we decided to split the 1m (1.2 m) snow cores in 3 (4) pieces to allow to quantify and correct for trends in the impurity or isotopic composition of the upper meter.

In order to recover the samples in the available time window, we split into two teams. One team went with the traverse train to the envisaged sites and used the carbon liners and shovels to collect the 10 samples per site (Sampling a). The second team used the skidoo and a newly developed sampling tool (Sampling b). Finally, at the field camp sites we additionally recovered 6x1m liner samples to resolve the vertical structure (Sampling c), as well as a 60m long transect of high-resolution surface snow samples (Sampling d).

The principle of Sampling a) consists for each location by recovering 10 snow cores along a 90 meter long trench using snow-pits created by the Pistenbully. A liner, (carbon fiber tube) of 5 cm diameter and 120 cm long is pushed down into the snow pack before being dug out using shovels. After withdrawing the cores from the snow (Fig. 5.4.3), four different parts of each core corresponding to the depth sections 0-33 cm, 33-66 cm, 66-99 cm, 99-120 cm were pushed out into 4 corresponding buckets. All the cores depths sections were then mixed together manually, and 2 small amounts of each depth section were collected and packed into sealed plastic bags.

Fig. 5.4.3: Sampling technique a) of recovering 1.2m snow cores using snow-pits created by the Pistenbully. The photo shows the moment of the removal of the filled snow liner from the snow-pit

The technique of sampling b) involved a new tool specially developed for this purpose in order to allow collecting small amount of the three depth sections 0-33 cm, 33-66 cm, and 66-99 cm. Through a mechanical approach, the tool avoids the use of electricity and potential issues in such extreme and isolated conditions. Two 120 cm-long juxtaposed carbon fiber tubes, of respectively 10 cm diameter and 5 cm for the snow sample, are pushed 1 meter down into the snow pack. The snow within the 10 cm diameter tube is then removed using a mechanical drill in order to allow inserting a mechanical structure inside the 1m deep hole (Fig. 5.4.4). This structure has been designed to position a 5 cm diameter blade at the bottom of the both tubes. Then, through a 180 degrees rotation, the blade cut the snow as well as covering the sample tube end to prevent the loss of snow sample while lifting up. Then, in a second step the collection of the 3 depth windows samples is realized. This step is realized by pushing 3 parts of the core sample out of the liner into sealed plastic bags. In this step, a longitudinal cut is realized to minimize the amount of sample collected. In future campaigns, Sampling method b could be performed with multiple devices and thus replace the Sampling method a that relies on a Pistenbully.

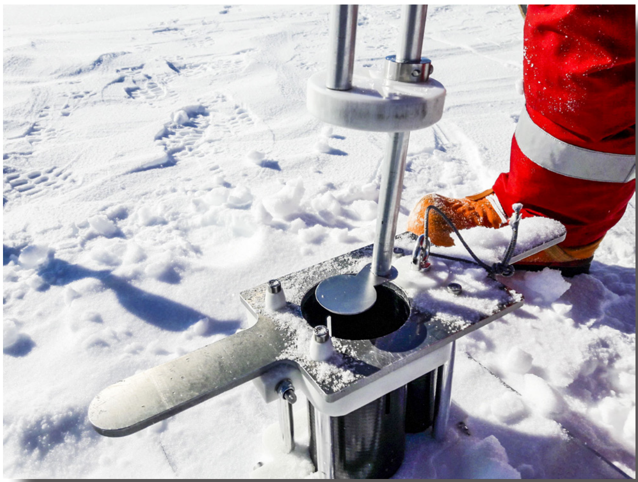


Fig. 5.4.4: Sampling technique b) of recovering 1m snow cores using the newly developed sampling tool. The photo shows the moment of the insertion of the mechanical structure inside the 1m deep hole that holds the blade and is used to cut the snow-core.

At the field camp site, we further sampled six one meter carbon snow liners that were carefully packed filled with snow and cut into discrete snow samples at *Kohnen Station* (sampling c). Finally, to test if the surface topography is predictive for the noise level, we further characterized the surface on a 60 m line by manually measuring the height profile, as well as taking surface snow samples every 2 m in total 31 samples (sampling d). The height reference was established using a theodolite.

Expected results

We sampled in total 430 m of snow and additional surface samples together with 350 km of radar profiles. This collection will allow us to investigate the effect of short-scale variations in accumulation rate on the average concentrations of stable water isotopes and trace components.

We expect that the relationship of local topography, accumulation conditions and spatial variations in the surface isotopic signal that we will obtain will assist the interpretation of existing firn cores and allow to optimize the sites for further firn/ice coring. It will further allow to develop a statistical model for the regional isotopic non-climate variations, needed to correct climate variability estimates from firn-cores. Finally, the dataset will allow to test the hypothesis of the AWI strategy fund project COMB-i that the information from impurity and isotopic variations can be combined to detect and correct for seasonal accumulation effects

The number of samples and thus their potential statistically significance is unique and was only possible by a) the new developed sampling tool and b) the help of the Logistic enabling us to split the team and collect different sites in parallel in a very short time.

Data management

All data collected and generated by this project will be made publicly available via the World Data Center PANGAEA Data Publisher for Earth & Environmental Science (www.pangaea.de).

References

Eisen O, Rack W, Nixdorf U & Wilhelms F (2005) Characteristics of accumulation around the EPICA deep-drilling site in Dronning Maud Land, Antarctica. Ann. Glaciol, 41(1), 41–46.

Ekaykin A, Eberlein L, Lipenkov V, Popov S, Scheinert M, Schröder L & Turkeev A (2016) Non-climatic signal in ice core records: lessons from Antarctic megadunes. The Cryosphere, 10(3), 1217–1227, doi:10.5194/tc-10-1217-2016.

EPICA community members (2006) One-to-one coupling of glacial climate variability in Greenland and Antarctica. Nature, 444(7116), 195–198, doi:10.1038/nature05301.

Fujita S et al. (2011) Spatial and temporal variability of snow accumulation rate on the East Antarctic ice divide between Dome Fuji and EPICA DML. The Cryosphere, 5(4), 1057–1081, doi:10.5194/tc-5-1057-2011.

Graf W, Oerter H, Reinwarth O, Stichler W, Wilhelms F, Miller H & Mulvaney R (2002) Stable-isotope records from Dronning Maud Land, Antarctica. Ann. Glaciol, 35(1), 195–201.

Helsen MM, van de Wal RSW, van den Broeke MR, Van As D, Meijer HAJ & Reijmer CH (2005) Oxygen isotope variability in snow from western Dronning Maud Land, Antarctica and its relation to temperature. Tellus B, 57(5), 423–435.

Jones, JM et al (2016) Assessing recent trends in high-latitude Southern Hemisphere surface climate. Nat Clim Change, 6(10), 917–926, doi:10.1038/nclimate3103.

Karlöf L, Winebrenner DP & Percival DB (2006) How representative is a time series derived from a firn core? A study at a low-accumulation site on the Antarctic plateau. J Geophys Res, 111(F4), doi:10.1029/2006JF000552.

Laepple T & Huybers P (2013) Reconciling discrepancies between Uk37 and Mg/Ca reconstructions of Holocene marine temperature variability. Earth Planet Sci. Lett, 375, 418–429, doi:10.1016/JepsL2013.06.006.

Laepple T, Hörhold M, Münch T, Freitag J, Wegner A & Kipfstuhl S (2016) Layering of surface snow and firn at Kohnen Station, Antarctica: Noise or seasonal signal? J Geophys Res Earth Surf, 2016,JF003919, doi:10.1002/2016JF003919.

Laepple T, Münch T, Casado M, Hoerhold M, Landais A, & Kipfstuhl S (2018) On the similarity and apparent cycles of isotopic variations in East Antarctic snow pits. The Cryosphere, 12(1), 169–187. doi:10.5194/tc-12-169-2018

Münch, T Kipfstuhl S, Freitag J, Meyer H & Laepple T (2016) Regional climate signal vs local noise: a two-dimensional view of water isotopes in Antarctic firn at Kohnen Station, Dronning Maud Land. Clim Past, 12(7), 1565–1581, doi:10.5194/cp-12-1565-2016.

Münch T & Laepple T (2018) What climate signal is contained in decadal- to centennial-scale isotope variations from Antarctic ice cores? Climate of the Past, 14(12), 2053–2070. doi:10.5194/cp-14-2053-2018.

Oerter H, Graf W, Meyer H & Wilhelms F (2004) The EPICA ice core from Dronning Maud Land: first results from stable-isotope measurements. Ann. Glaciol, 39(1), 307–312.

Rotschky G, Eisen O, Wilhelms F, Nixdorf U & Oerter H (2004) Spatial distribution of surface mass balance on Amundsenisen plateau, Antarctica, derived from ice-penetrating radar studies. Ann. Glaciol, 39(1), 265–270.

Koch BP & Dittmar T (2006) From mass to structure: An aromaticity index for high-resolution mass data of natural organic matter. Rapid communications in mass spectrometry, 20, 926-932.

5.5 SNOB – Long-term SNowpack OBservation at Kohnen: Climate signal formation and snow metamorphism

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Objectives

Knowledge about processes within the snowpack is crucial for the interpretation of climate proxy records retrieved from polar ice cores on centennial, decadal or even shorter time scales. In particular in areas of low annual snow accumulation like the area around *Kohnen Station* on the East Antarctic plateau the seasonal distribution in deposition, the amount of re-deposition and metamorphism of snow affect the way how the climate signal and its temporal evolution is archived in the buried snow layers.

In the history of polar research a tremendous amount of snowpack investigations had been performed where vertical profiles of snow structure (its stratigraphy) were studied visually on polished pit walls. The specific structure of a buried snow layer carries a time-integrated information about climate conditions starting from time of deposition and ending at present age. The complexity of the involved processes and its spatial variability explains why the qualitative description of former studies could not retrace climate conditions in detail. However, the potential of snow structure for dating issues is shown in several studies (Körner, 1971; Alley, 1988). Larger temporal and spatial scales are investigated using firn cores and ground penetrating radar (GPR) methods (Eisen et al., 2008; Anschütz et al., 2009; Fujita et al., 2011). Accumulation has been measured by stake farms at several locations in Antarctica showing inter-annual and strong intra-annual variations at some sites (Murayama, 1971; Frezzotti et al., 2005). Observations from the last summer field expeditions (pers. comm. Sepp Kipfstuhl) and the recent study of Picard et al. (2012) suggest large intra-annual variations for the area around *Kohnen Station*. Despite these observations, the seasonal and interannual accumulation variability on the East Antarctic Plateau is unclear, leading to ambiguous interpretations of the climate signal in ice-core records (Laepple et al., 2011; Sime et al., 2011; Laepple et al. 2016; Münch et al. 2016).

The objectives of this project are

- to quantify the metamorphism/changes in microstructure with time at *Kohnen Station* using core-scale X-ray computer tomography
- to quantify redistribution of snow at *Kohnen Station* using a 3D-laser scanner system
- to interpret the 20-year-profiles of chemical load and isotopic composition of snow as climate proxy parameters (link to projects ASTI and KOHNEN-QK-1, ANT-Land18/19) and
- to compare them with 20 years of weather data measured by the automatic weather station (AWS9) at *Kohnen Station*

To this end an extensive snow sampling program is initiated with a long-term perspective of snowpack observations at *Kohnen Station*. It addresses the temporal evolution of the snow pack which includes observations of surface relief, seasonal accumulation, snow structure properties, chemical load and isotopic composition typically used as climate proxy parameters. The target of research is the upper 4 meter of snowpack which corresponds to the amount of fallen snow during 20 years of operation of *Kohnen Station*. Designated areas in the vicinity of

Kohnen Station have been assigned for repeated sampling of snowpack over the next years to follow its development with time. The project makes use of the recent analytical progress in determining snow microstructure on a cm- to m-scale (AWI-Ice-Xray CT) and of the larger capacities in measuring chemical load and isotopic composition.

Fieldwork

The project was carried out within the time period between 15 December 2018 and 24 January 2019 in the vicinity of *Kohnen Station*. The designated areas for long-term snow sampling are the positions IP1-5 and the TLP-Trench (coordinates listed in Table 5.5.1). The positions were formerly sampled during the last *Kohnen* expedition in 2016/17. The snow was sampled with the means of hard, thin-walled carbon-fiber tubes of 1 m length and 10 cm diameter. The tubes were gently pushed into the snow surface. They were sidelong taken out after digging a small snow pit close to the buried tube (Fig. 5.5.1). The lower and upper ends of the tube were covered by clean plastic bags. The tubes with the snow sample inside were packed immediately after retrieval in ice core boxes and kept frozen. The boxes were shipped to Bremerhaven via aircraft and ship. Temperature loggers in the boxes documented the temperature history of the samples.

Tab. 5.5.1: Sampling sites around *Kohnen Station*

Sampling site	Set up	Long	Lat
IP 1-5 transect	2012/13..16/17	0.00733293	-75.0025
TLP_trench	2016/17	0.0852	-75.0075
T4M-trench	2018/19	0.11053	-75.02109
Snow field/3d-laser scanning	2018/19	0.10233	-75.01704

Fig. 5.5.1: Snow sampling at the TLP-trench wall using carbon-fiber tubes

At the IP1-5 positions the upper 2 m of the snow column was sampled using 2 tubes for each site. The TLP-trench was sampled along a transect of 10 m every 0.5 m. The trench was excavated to 1 m depth after pushing the tubes into the undisturbed surface Afterwards the depth interval between 1-2 m was sampled and the excavation extended to 2 m depth. During trench preparation the old positions from sampling 2016/17 became visible because the stratigraphy of undisturbed snow is different from that of crushed refilled snow. It allows to revisit the same sampling spot within a few centimetres. The microstructure and snow density of all samples from IP1-5 and TLP will be analysed in Bremerhaven with the means of the AWI-Ice-X-ray-CT (Freitag et al., 2013). The structure data will be compared with the data from the same spots from the year before to quantify changes in microstructure.

The upper 4 m of the snowpack was sampled along the T4M-Trench using the carbon-fiber tube technique as described above. The T4M-Trench was excavated by a Pistenbully down to 4 m depth using a snow bucking plate (Fig. 5.5.2). The snow wall was successively sampled every 5 m over a total distance of 50 m. Then the snow from the tube samples was horizontally cut into 1.1 cm (upper 30 cm-snowpack) and 3 cm-subsamples, respectively. The subsamples were collected into plastic bags, shipped as frozen samples to Bremerhaven for isotope and impurity analysis. Three 4m-profiles of snow tube samples were shipped to Bremerhaven as 1m-pieces for microstructure analysis. The trench walls were polished and the stratigraphy of the snow layers was visually recorded. The height of the snow surface against a horizontal reference was measured along the transect at every sampling position.

Fig. 5.5.2: The excavated 50 m long and 4 m deep T4M-trench

The data logger of the automatic weather station (AWS9) at Kohnen was excavated and the measured data of the last years collected. Afterwards the station was lifted up to the maximum of 2.25 m above surface to maintain its operation for the next years.

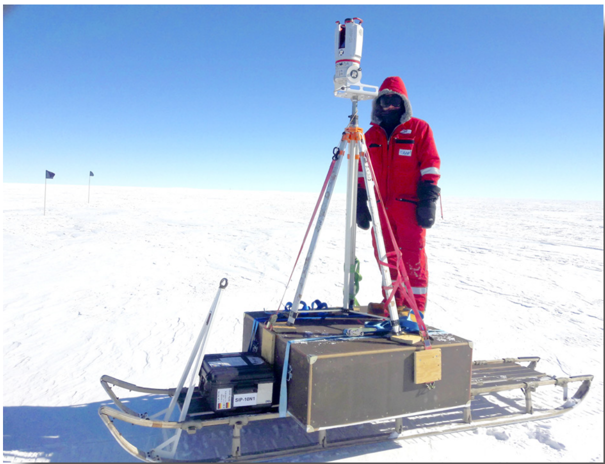

Fig. 5.5.3: The 3d-laser scanner device Riegl VZ400i in operation on a sledge

A 3d-laser scanner (Riegl VZ400i, Riegl company, Austria) was used for measuring snow surface topography at *Kohnen Station*. A single scan covers the surface relief of an area of about 20 m x 20 m. The recording time of one 360degree-scan is 30 s. The 3d-scanning was applied to a designated snow field of 60 x 200 m^2. The instrument was locked in 2 m height on a tripod mounted on a sledge (Fig 5.5.3). The sledge was pulled by a snowmobile. The snowmobile stopped during recording. The snow field was marked with 30 reflector sticks. The snow field has been scanned in three transects 20 m apart from each other. Scans are performed every 5 m along a transect. The snow field was scanned three times within the expedition period including the largest storm event recorded at *Kohnen* over the last 20 years at the 20 January 2019 with wind speeds close to 40 kn. A comparison between the measured surface reliefs from different time intervals will be performed to quantify the redistribution of snow.

Preliminary results

The histogram of daily temperatures at *Kohnen station* over the last 20 years shows a wide range between -15.6°C and -71.0 °C with the mean of -42.5°C (Fig. 5.5.4). The cold temperature periods during winter are characterized by strong day to week-long events of high temperature introduced by a sudden increase of up to 30°C (Fig. 5.5.5, day 120 for example). The high temperature events are typically associated with high wind events. It is found that at *Kohnen Station* the annual mean temperature is rising by about 1.5°C for each decade mainly driving by an extraordinary increase of summer temperatures (Fig. 5.5.6). The winter period shows only large interannual fluctuations without any significant trend over the last two decades of observations. The annual wind speed is 4-5 m/s and shows no decadal trend. Mean wind speed and the frequency of extreme events averaged for summer and winter periods show large interannual scatter with less wind and extreme events during summer but no trends over the decades (Fig.5.5.7).

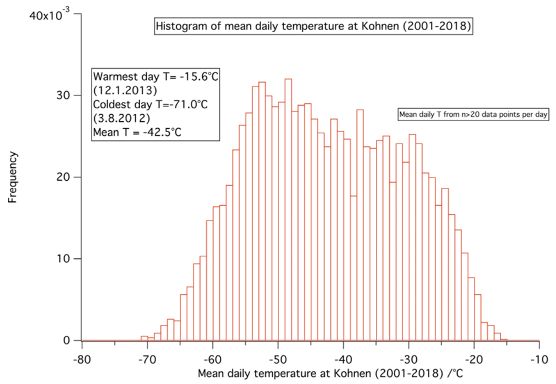

Fig. 5.5.4: Histogram of daily temperatures at Kohnen Station over the time interval 1998-2018 recorded by the automatic weather station AWS9

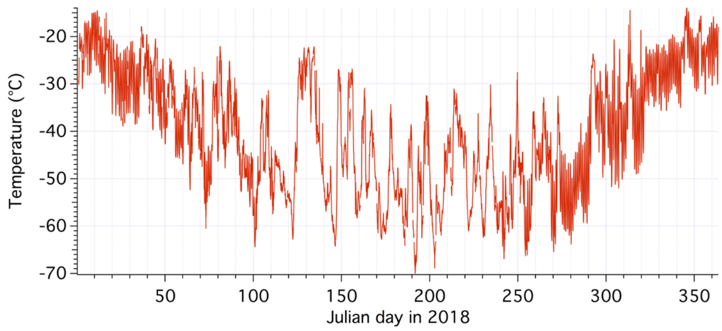

Fig. 5.5.5: Seasonal temperature cycle of year 2018

The operation of the 3d-Laser scanner in the Antarctic environment at *Kohnen Station* was successfully tested in respect to the performance under cold temperatures (less than -20°C) and in respect to the reflectivity of cold aged snow. Because of the self-leveling function of the instrument it is very convenient and fast (30s) to scan surface undulations. Fig. 5.5.8 shows an example image of the snow surface after a 30s-360degree scan. The height is color-coded with depressions in blue and hills in red with a total vertical range of around 20 cm. The positions of the snowmobile and the sledge are out of the colored range and therefore indicated as white spots. Reference flags are white colored also because their dimensions are larger than 20 cm as well. The reference flags will be used to assemble different images to a unique surface plot over the whole snow field. The trace of the sledge in the snow is clearly identifiable and shows that the spatial resolution is in order of centimeters in the inner circle of a few meters.

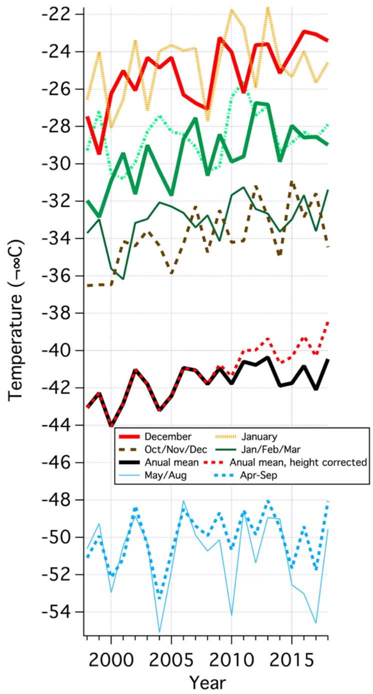

Fig. 5.5.6: Annual temperature over the time interval 1998-2018

Further expected results

The analysis of the snow samples will provide isotope and impurity records as climate proxy parameter over the upper 0 - 4 m of snowpack with a spatial resolution of 1.1/3.3 cm. The X-Ray measurements of the AWI-Ice-Xray-CT will provide density and microstructure of the upper snowpack (0 - 4 m) in submillimeter resolution and will be used to quantify temporal changes due to metamorphism and sintering. The snow data will cover the characteristics of the snow that was buried over the last 20 years. They will be the basis for the comparison with the measured data of the weather station at *Kohnen Station*. This comparison study between the climate archive of snow and the real weather conditions over several decades will be the first study of that extent in a low-accumulation area of the Antarctic ice sheet.

The 3d-laser data will be compiled for the whole snow field for the different time slots. They will be used to quantify the redistribution during summer and especially after the largest storm event that was recorded within the last 20 years at *Kohnen Station*.

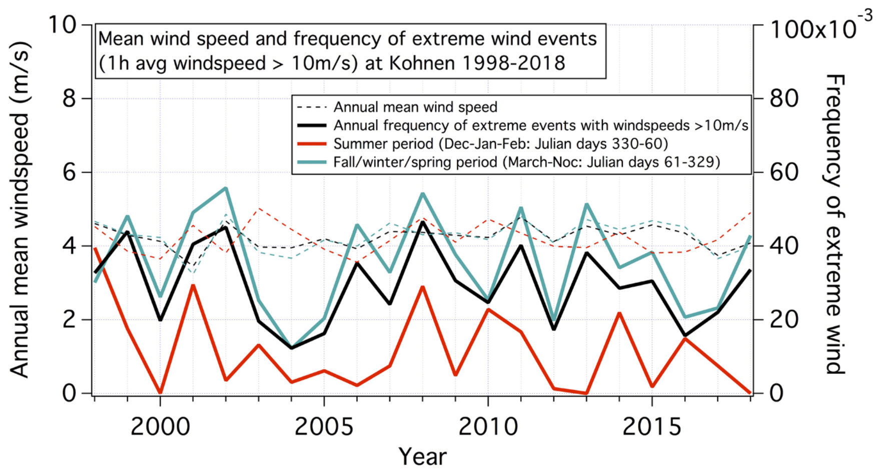

Fig. 5.5.7: Annual wind speed and frequency of extreme wind events over the time interval 1998-2018

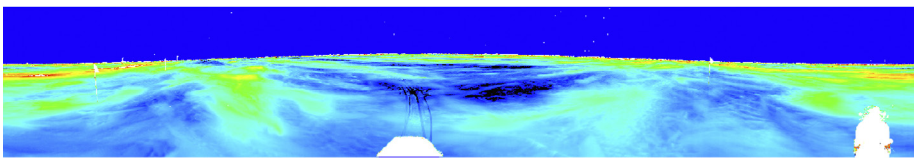

Fig. 5.5.8: Example of the surface relief derived from the 3d-laser scanner RIEGL-VZ400i. The surface heights are color coded with depressions marked in blue, rises marked in red.

Data management

All data collected and generated by this project will be made publicly available via the World Data Center PANGAEA Data Publisher for Earth & Environmental Science (www.pangaea.de).

References

Alley RB (1988) Concerning the deposition and diagenesis of strata in polar firn. J Glaciol, 34 (118), 283-290.

Anschütz H, Müller K, Isaksson E, McConnell JR, Fischer H, Miller H, Albert M & Winther J-G (2009) Revisiting sites of the South Pole Queen Maud Land Traverses in East Antarctica: Accumulation data from shallow firn cores. J Geophys Res, 114, D24106, doi:10.1029/2009JD012204.

Eisen O, Frezzotti M, Genthon C, Isaksson E, Magand O,Van den Broeke, M R, Dixon DA, Ekaykin A, Holmlund P, Kameda T, Karlöf L, Kaspari S, Lipenkov V, Oerter H, Takahashi S & Vaughan DG (2008) Ground-based measurements of spatial and temporal variability of snow accumulation in East Antarctica. Rev. Geophys, 46, RG2001,doi:10.1029/2006RG000218.

Freitag J, Kipfstuhl S & Laepple T (2013) Core-scale radioscopic imaging: a new method reveals density-calcium link in Antarctic firn. J GlacioL, 59 (218), pp. 1009-1014 . doi: 10.3189/2013JoG13J028.

Frezzotti M, Pourchet M, Flora O, Gandolfi S, Gay M, Urbini S, Vincent C, Becagli S, Gragnani R, Proposito M, Severi, M Traversi R, Udisti R & Fily M (2005) Spatial and temporal variability of snow accumulation in East Antarctica from traverse data. J Glaciol, 51, 113–124.

Fujita S, Holmlund P, Andersson I, Brown I, Enomoto, H, Fujii Y, Fujita, K, Fukui K, Furukawa T, Hansson M, Hara K, Hoshina Y, Igarashi M, Iizuka Y, Imura S, Ingvander S, Karlin, T Motoyama H, Nakazawa F, Oerter H, Sjöberg L E, Sugiyama S, Surdyk S, Ström J, Uemura R & Wilhelms F (2011) Spatial and temporal variability of snow accumulation rate on the East Antarctic ice divide between Dome Fuji and EPICA DML. The Cryosphere, 5, 1057-1081, doi:10.5194/tc-5-1057-2011.

Koerner R (1971) A stratigraphic method of determining the snow accumulation rate at Plateau Station, Antarctica, and application to South Pole Queen Maud Land Traverse 2, 1965– 1966, in Antarctic Snow and Ice Studies II. Antarct Res Ser, vol 16, edited by A P. Crary, pp. 225– 238, AGU, Washington, DC.

Laepple T, Werner M & Lohmann G (2011) Synchronicity of Antarctic Temperatures and Local Solar Insolation on Orbital Timescales. Nature 471 (7336): 91–94. doi:10.1038/nature09825.

Laepple T, Werner M & Lohman G (2011) Reply to 'Antarctic accumulation seasonaluty. Nature 479 (7372): E2–4. doi:10.1038/nature10614.

Laepple T, Hörhold M, Münch T, Freitag J, Wegner A & Kipfstuhl S (2016) Layering of surface snow and firn at *Kohnen Station*, Antarctica: Noise or seasonal signal? J Geophys Res Earth Surf, 121, 1849–1860, doi:10.1002/2016JF003919.

Münch T, Kipfstuhl S, Freitag J, Meyer H & Laepple T (2016) Regional climate signal vs local noise: a two-dimensional view of water isotopes in Antarctic firn at *Kohnen Station*, Dronning Maud Land. Clim Past, 12, 1565-1581, doi:10.5194/cp-12-1565-2016.

Murayama M (eds) (1971): Report of the Japanes Traverse Syowa-South Pole, 1968-1969, 1-279, Japanese Antarctic Research Expedition, Scientific Reports, Spec Issue (2).

Picard G, Domine F, Krinner G, Arnaud L & Lefebvre E (2012) Inhibition of the positive snow-albedo feedback by precipitation in interior Antarctica. Nature Climate Change, 2 (11), 795-798, doi:10.1038/nclimate1590.

Sime L C & Wolff E W (2011) Antarctic accumulation seasonality. Nature 479 doi:10.1038/nature10613.

6. FLIGHT CAMPAIGNS *POLAR 6*

6.1 AIRLAFONIA – Aerogeophysical test of the Lafonia plate hypothesis

Graeme Eagles, Hannes Eisermann AWI

Objectives

AIRLAFONIA (Aerogeophysical test of the Lafonia plate hypothesis)

Large paleomagnetic rotations and regional geological correlations from the Falkland Islands, South Georgia, and Antarctica's Ellsworth Mountains are of fundamental significance for studies of Gondwana paleogeography and breakup, but this significance has been debated vigorously since early in the twentieth century. One interpretation involves the formation and large-scale rotation of small lithospheric plates. One of these plates, termed the Lafonia Mircoplate, is suggested to have borne the Falkland Islands and caused them to rotate by a full 180°, opening the Falkland Plateau Basin between the Falklands and Maurice Ewing Bank, 1,000 km to the east, in the process (Ben Avraham et al., 1993). AIRLAFONIA was designed to test for the occurrence of this rotation by searching the floor of the Falkland Plateau Basin for the presence of the curved pattern of magnetic reversal isochrons and fracture zones that it would have left.

AIRLAFONIA within AWI

Plate motion is the single largest influence on paleogeography, which in turn is of fundamental significance for paleo-circulation and paleoclimate modelling studies. AIRLAFONIA is thus closely integrated with the long-term aim of the AWI geophysics department, within the PACES programme Topic 3, Work-package 2, to investigate the earth system on tectonic timescales. Furthermore, it builds on the results of *Polarstern* expedition ANT-XXIX/5 (PS81), which established the presence of igneous crust beneath the Falkland Plateau Basin, and thus its suitability for plate kinematic analysis by the generation of a new aerogeophysical dataset.

Fieldwork

AIRLAFONIA was initiated for the 2017/18 season, having been set up rapidly early in 2017 in excellent cooperation with the Falkland Islands Government. A combination of unsuitable weather and technical difficulties saw the completion of just 37.7 flying hours from a planned total of at least 80. Alongside permanently-installed meteorological and camera systems, *Polar 6* was equipped with an airborne gravimeter (Gravimetric Technologies GT-2A) and tail-mounted caesium vapour magnetometer (Scintrex Cs-3).

The 2018-19 season saw AWI's agreement with the Falkland Islands Government renewed, with the intention of completing AIRLAFONIA. *Polar 6*, identically configured as in the 2017-18 season, completed the planned acquisition with a further 43.1 hours of air time in the period between November 3 and November 30, 2018. Configuration was completed at a hardstanding next to the air traffic control tower at RAF Mount Pleasant Airport, a 40 minute drive away from the team's accommodation at Port Stanley. All flights started and ended at Mount Pleasant.

Fig. 6.1.1 summarizes the completed flight pattern, consisting of a large set of east-west parallel flights designed to maximize coverage of the Falkland Plateau Basin, and a smaller number of NE-directed paths providing tie-line constraint on the east-west lines.

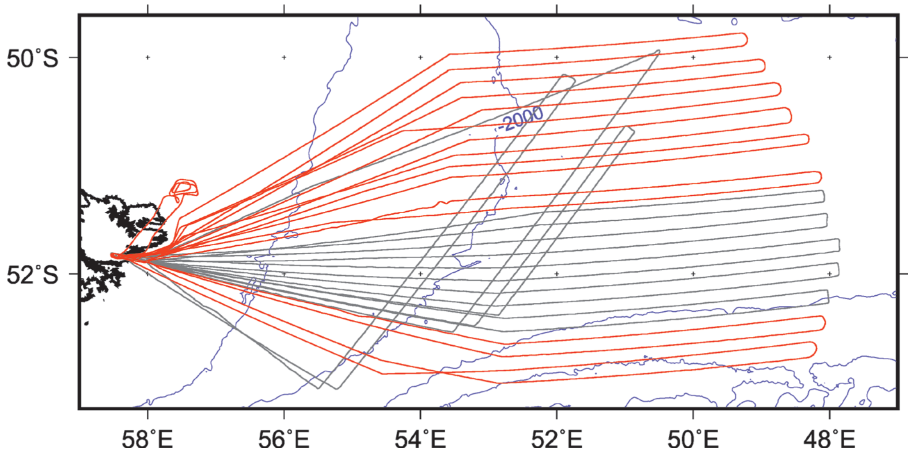

Fig. 6.1.1: Map of completed flight lines during both AIRLAFONIA campaigns (2018-19 lines in red)

Preliminary results from AIRLAFONIA

The gravimeter performed according to expectations on all of the 2018-19 flights. The data reveal a prominent free-air gravity high at the Falkland Plateau Basin's western margin with the Falkland Islands shelf, and a smooth gravity field over most of the rest of the basin. This is consistent with a broad extent for the relatively homogeneous igneous crust reported along *Polarsterns* ANT-XXIX/5 (PS81) track in 2013 (Schimschal & Jokat, 2018). The magnetic data reveal stronger variability in the magnetic field over the basin. A prominent two-peaked anomaly coincides with the western basin margin. Over the basin floor, there is a tendency for anomaly amplitudes and wavelengths to be lower and longer in the west, and higher and shorter in the east. Preliminary interpretation and modelling of these variations in terms of the plate kinematics, to test the Lafonia plate hypothesis, are underway.

Acknowledgements

We thank the crew of *Polar 6* Dean Emberley (captain), Chris Bracker (co-pilot), Eric Prager (aircraft engineer) and system engineers Christoph Petersen and Cristina Sans-Coll for their excellent support in the field. We also thank our numerous advocates and hosts in the Falkland Islands, Falkland Islands Government, and Royal Air Force at Mount Pleasant Airport.

Data management

The navigation master tracks are archived in the World Data Center PANGAEA Data Publisher for Earth & Environmental Science (www.pangaea.de). After full analyses the magnetic and gravity data will be archived at AWI according to the policies and formats of the geophysics section. Following publication, these data will be made available upon request to the geophysics section.

References

Ben Avraham Z, Hartnady CJH & Malan JA (1993) Early tectonic extension between the Agulhas bank and the Falkland plateau due to the rotation of the Lafonia microplate. Earth Planet. Sci. Lett. 117, 43-58.

Schimschal CM & Jokat W (2018) The crustal structure of the continental margin east of the Falkland Islands. Tectonophysics, 724-725, 234-253

6.2 CAPIS – Circum-Antarctic Platelet Ice Survey

Christian Haas[1], Anne Irvin[2]

[1]AWI
[2]YU

Objectives

The Antarctic sea ice cover is closely linked to ice-ocean interaction processes under ice shelves. The melt of ice shelves at their bottom creates Ice Shelf Water (ISW) which can rise to the water surface and can spread under adjacent landfast sea ice to form so-called platelet ice. This platelet ice forms an unconsolidated, porous layer under the sea ice whose electrical conductivity is larger than that of the overlying sea ice and less than that of the underlying sea water (Langhorne et al., 2015). The presence and thickness of the sub-ice platelet layer can therefore be observed by airborne electromagnetic induction (AEM) measurements (Haas et al., 2010). We successfully demonstrated the method in McMurdo Sound since 2009 and mapped the coast of the western Ross Sea in close collaboration with colleagues from Antarctica New Zealand. Now, CAPIS aims to map the occurrence of platelet ice along the coast of Dronning Maud Land to compile an inventory of locations and intensities of Ice Shelf Water outflow adjacent to ice shelves in that region. This will give new insights into the processes of bottom melt of ice shelves. The plan was to map the entire coast of the southeastern Weddell Sea between Novo and the Filchner Ice Shelf, using *Novo*, *Neumayer Station III* and *Halley* as operating bases.

A major challenge for CAPIS is the fact that in Dronning Maud Land aircraft can only be operated on skis. This required to acquire new aviation certificates to operate the AEM instrument, AWI's EM Bird, under the *Polar 6* when operated with skis. As the EM Bird is located under the fuselage of the aircraft (Fig. 6.2.1) it creates significant drag and therefore the take-off weight of the aircraft is lower than usual. This limits the survey time to three to four hours.

Fig. 6.2.1: Photo of EM Bird latched below the fuselage of the Polar 6 which is operated on skis (Photo © C. Haas). CAPIS was the first campaign ever where EM Bird flights were possible with skis.

Fieldwork

CAPIS took place between 28 November and 18 December, and was mainly based at *Novo Airbase* where the installation and de-installation of the EM Bird equipment were carried out. After a long, nine-day wait for the hugely delayed *Polar 6* the installation of the EM Bird and other science equipment was completed on 9 December. A first test flight had to be cut short due to upcoming fog at Novo. After a successful platelet ice survey to the northeast of Novo on 10 December, we transited to the Belgian *Princess Elisabeth Station* (PE). This was suggested by Prof. Jean-Louis Tison and decided on short notice due to continuing poor weather at *Neumayer Station III* and *Halley Station*. Our visit to PE was arranged on very short notice through the kind and swift support of the AWI logistics department and the welcoming PE station manager Alain Hubert which we gratefully acknowledge. From PE, two very successful surveys were carried out on 11 December. On 12 December we transited from PE to *Neumayer Station III* via a fuelling stop at Novo. Perfect survey weather conditions are forecast for *Neumayer Station III* on 13 December. After that the forecasts are uncertain for both, *Neumayer III and Halley* and further plans will be decided on short notice.

At the end of our ferry flight from PE to *Neumayer Station III* on 12 December we were warmly welcome by the *Neumayer Station III* base staff and numerous scientific colleagues.

December 13 was forecast to be the best surveying day in the Neumayer region and therefore we focused on conducting our priority surveys there. In the morning, a three-hour platelet ice survey of the fast ice to the east and in particular of Atka Bay was carried out. The goal of the surveys in Atka Bay was to complement *in-situ* measurements carried out throughout the winter by one of the wintering team members (Hanno Müller), as well as to obtain collocated ice thickness validation data along profiles that were surveyed by Stefanie Arndt, Jan Rohde, and Hanno Müller by ground-based EM measurements in the preceding two weeks as part of AWI's Antarctic Fast Ice Network (AFIN) activities.

The flight in the morning of 13 December also included a laser scanner grid survey of four prominent icebergs locked into Atka Bay and their characteristic snow accumulation distribution which result in prominent backscatter patterns in satellite radar imagery. These complement coincident *in-situ* snow thickness surveys carried out by the AFIN team.

In the afternoon of 13 December a four-hour long platelet ice survey was carried out farther to the East, including surveys of the fast ice west and east of the Fimbul Ice Shelf, reaching one of CAPIS' major 2018 objectives. The relatively long flight duration was possible because the altitude of the runway at *Neumayer Station III* is near sea level and because only two scientific personnel joined the flight.

In the morning of 14 December weather conditions were poor but we were able to carry out a short survey of the fast ice west and north of the Ekström Ice Shelf, and completed a final profile across Atka Bay. The flight was concluded by a laser scanner survey of *Neumayer Station III* itself, including the giant snow drifts that form in its vicinity.

Unfortunately, weather conditions at *Halley Station* and towards the Filchner Ice Shelf, CAPIS' highest priority survey regions, were always questionable or poor, and therefore we had to abandon our plans to go and survey from there. Instead, due to poor weather forecasts for the complete DML region we returned to Novo Runway in the afternoon of 14 December to have enough time for the de-installation of the EM Bird and to be ready for Anne Irvin's and Christian Haas' return to Cape Town scheduled for 18 December. Weather was questionable in the morning of 15 December and therefore we could not carry out a final survey. That survey would have filled the remaining regional gap between the Fimbul and Lazarev Ice Shelves where researcher from the Norwegian Polar Institute conduct related activities. Instead, we began to remove and pack the EM Bird and associated components in deteriorating weather. This work was completed in half a day by the efficient team work of the complete seven-person CAPIS team, and the aircraft was handed over ahead of time to the JuRaS/Chirp project.

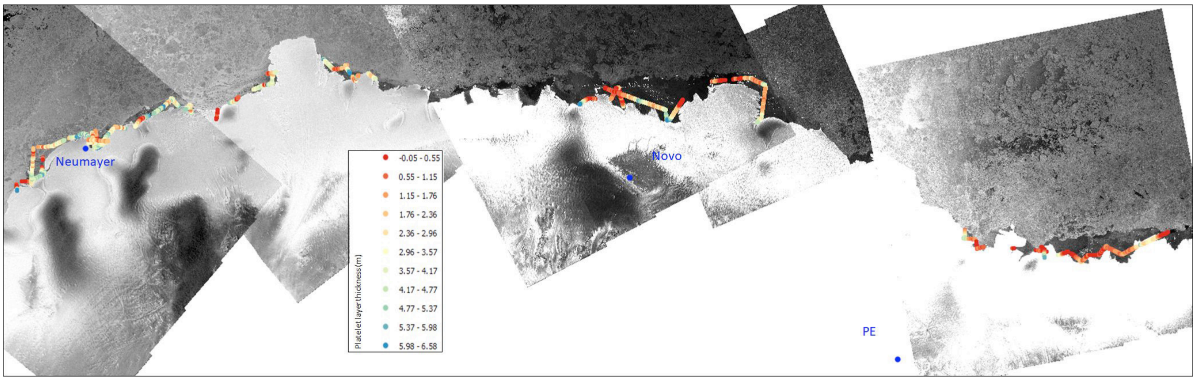

Fig. 6.2.2: Map of tracks of all six platelet ice surveys (Dec 9-14; red lines) as well as Neumayer, Novo and PE stations. Background shows contemporary Sentinel 1 SAR images (courtesy ESA, AWI-FramSat, and Stefanie Arndt).

Tab. 6.2.1 Summary of all activities and survey flight carried out during CAPIS 2018

Date	Activity	Flight hours
2018-11-28	Arrival at Novo Runway from Cape Town	
2018-11-29 – 2018-12-07	The team waited in Novo Runway for the arrival of the *Polar 6*, which arrived five days late from a survey in the Falkland Islands	
2019-11-30	Flight Manual Supplement approval for operation of EM Bird with skis	
2018-12-07 – 2018-12-09	Installation of EM Bird and other scientific instruments (e.g. laser scanner, KT19)	
2018-12-09	Test flight including short survey over sea ice north of Novo Runway where first occurrences of platelet ice were discovered	1:24
2018-12-10	Survey northeast of Novo;	2:47
	Ferry flight to *Princess Elisabeth Station* (PE).	1:33
2018-12-11	Two surveys north of PE	2:46 3:20
2018-12-12	Ferry PE-Neumayer via Novo Runway	3:54
2018-12-13	Two surveys east of Neumayer including Atka Bay and Fimbul Ice Shelf; including laser scanner survey of icebergs in Atka Bay	3:02 3:48
2018-12-14	Survey of fast ice west and north of Ekström Ice Shelf;	
	Laser scanner survey of *Neumayer Station*	2:19
	Return to Novo Runway	3:06
2018-12-15	De-installation of EM Bird	
2018-12-18	Anne Irvin and Christian Haas leave for Cape Town	
	Arrival of JuRaS/Chirp project team	
	Total	**27:59**

Preliminary results

Sub-ice platelet layers were found in front of most ice shelves and ice tongues, however, their thicknesses and spatial extents were highly variable owing to different ice shelf and sub-ice cavity thicknesses and geometries, and outflow regimes. Fig. 6.2.3 shows an example of a narrow plume discovered adjacent to the Lazarev Ice Shelf.

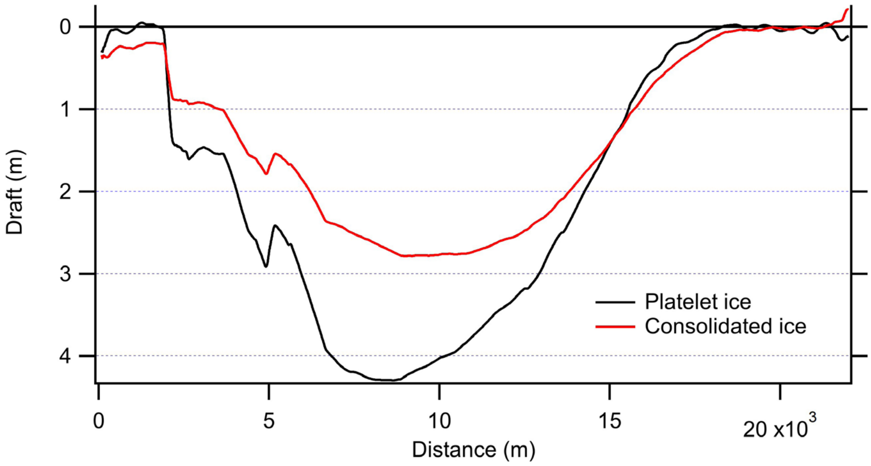

Fig. 6.2.3: Typical fast ice and platelet ice thickness profile adjacent to the Lazarev Ice Shelf. Red line show bottom of consolidated landfast sea ice. Black line shows bottom of platelet layer.

Fig. 6.2.4 and 6.2.5 show a preliminary comparison of platelet ice thicknesses surveyed along the same profile across Atka Bay by CAPIS (airborne) and AFIN (ground-based, using an EM31 instrument). It can be seen that the ground-based measurements represent the average platelet ice thickness well. However, there is more detail in the airborne data which more clearly show more deformed ice in the West, and which indicate the presence of a subtle double plume of platelet ice with bulges in the West and East.

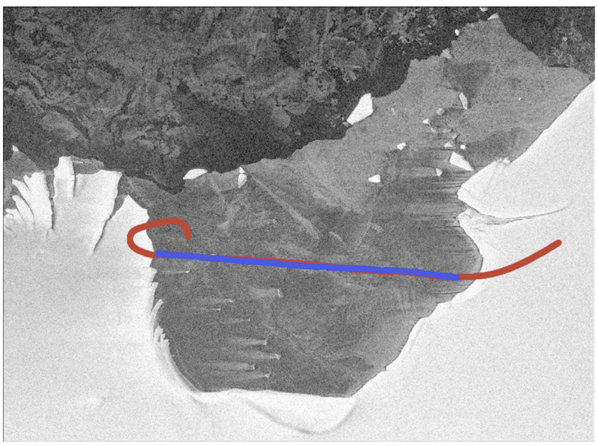

Fig. 6.2.4: Sentinel 1 SAR image showing Atka Bay and the track of one of the coincident ground-based (blue) and airborne ice thickness surveys. The profiles are compared in Fig. 6.2.3. SAR image courtesy ESA and AWI-FramSat.

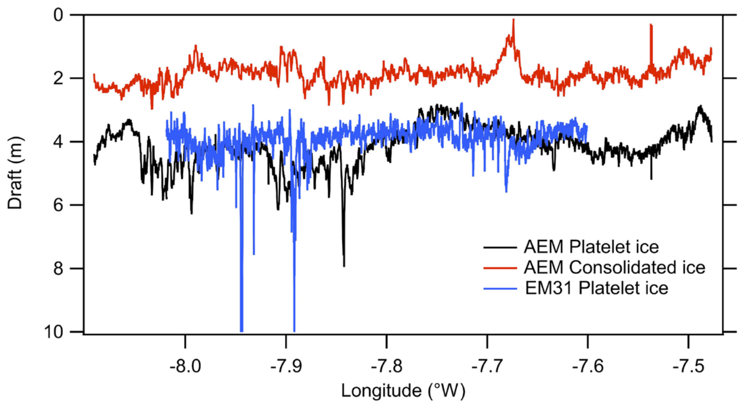

Fig. 6.2.5: Preliminary comparison between airborne and ground-based (EM31) platelet ice measurements along a transect across Atka Bay (Fig. 6.2.4)

Conclusions

Despite the initial delays and ever-present weather challenges CAPIS has proven quite successful. Not only were unique, large-scale platelet ice data acquired for the first time, but the activity also proved very feasible. Even with skis it was possible to reach most fast ice locations along the coast of Dronning Maud Land. In addition, traveling between different operating bases proved feasible and efficient due to the good connection and cooperation between the different national Antarctic programs. We will therefore work on extending CAPIS' regional scope in the future to include surveys to the Filchner-Ronne Ice Shelf in the West and the Amery Ice Shelf in the East, using *Halley*, *Syowa*, and *Davis* stations, and other bases further east.

Including surveys over Atka Bay has provided valuable opportunities for the validation of the airborne surveys, in addition to what has already been done in McMurdo Sound.

Acknowledgements

We would like to thank the various people who contributed to the preparation and success of CAPIS, in particular Daniel Steinhage, Christine Wesche, Uwe Nixdorf, Jan Rohde; staff and scientists at *Neumayer Station III*, *Novo*, and *PE stations*; as well as staff at Kenn Borek Air, Lake Central, and the *Polar 6* Hangar, among them Martin Gehrmann and Sebastian Spelz, and our air crew Will Wilson, Chris Bracker, and Erik Prager.

Data management

After full analyses the data will be made available in the World Data Center PANGAEA Data Publisher for Earth & Environmental Science (www.pangaea.de).

References

Haas C, Hendricks S, Eicken H, Herber A (2010) Synoptic airborne thickness surveys reveal state of Arctic sea ice cover, Geophysical Research Letters, 37, L09501, 5 p., doi:10.1029/2010GL042652.

Langhorne PJ, Hughes KG, Gough AJ, Smith IJ, Williams MJM, Robinson NJ, Stevens CL, Rack W, Price D, Leonard GH, Mahoney AR, Haas C & Haskell TG (2015) Observed platelet ice distributions in Antarctic sea ice: An index for ocean-ice shelf heat flux. Geophys. Res. Lett., 42, 5442–5451, doi:10.1002/2015GL064508.

6.3 JURAS & CHIRP

D. Jansen[1], S. Franke[1], O. Eisen (in the field elsewhere)[1], R. Drews (in the field elsewhere)[2]

[1]AWI
[2]University of Tübingen

Objectives

JuRaS (Jutulstraumen Radar Stratigraphy)

Ice streams provide the most efficient drainage of ice into the sea (e. g. Alley et al., 2005). They are highly dynamic systems, sensitive to changes in boundary conditions at their outlets or at their base. The consequences of changes at the outlets, e.g. due to ocean warming, can reach far upstream, as has been observed for the Pine Island Glacier, West Antarctica (Joughin et al., 2010). The temporal and spatial variability of ice streams is currently not well understood, and thus these rapid dynamic changes are not well represented in large scale models used to predict future sea level rise (Alley et al., 2005).

The ice streams not only leave their imprint on the surface, but also show up within radar-mapped stratigraphy of the ice sheets. They leave their associated structures buried in the ice to reveal their former presence, even if flow conditions have changed. Focus of this project was to map the disturbances of the radar stratigraphy at the shear margins of the Jutulstraumen, a large outlet glacier in Dronning Maud Land (DML), Antarctica, as well as within its main trunk. This project will help to improve our understanding of the formation processes of such disturbances around shear margins in active ice streams. A better understanding of the process itself will enable to analyse the observed structures in other parts of the ice sheets in terms of their deformation history.

CHIRP (Channel and Ice Rise Project in DML)

The properties of grounding lines determine the overall flux of grounded ice into the ocean. Changes in grounding line dynamics can results in sea-level change, if unbalanced by respective changes in the surface mass balance of the ice sheet. This project aims to acquire airborne data with AWI's UWB (ultrawideband) radar to investigate important aspects which define the dynamics of the sheet-shelf system in DML, Antarctica. This includes several ice rises, which serve as breaks for unhindered ice-shelf flow as well as a particular site just upstream of the grounding line, where strong interaction between a sediment-carrying, subglacial hydrological network, the ocean and the ice sheet are suspected. The data will lay the ground to constrain estimates of past ice flow and to understand stabilizing/destabilizing mechanisms in the most critical zone around Antarctica. Both aspects will result in improved predictions under future climate change.

Fieldwork

From 18.12.2018 to 10.01.2019, *Polar 6* operated in the DML area in Antarctica, using the ultra-wideband radar system (UWB) developed by the Center for Remote Sensing of Ice Sheets (CReSIS), Kansas. Additional to the radar data, we collected ice sheet elevation data with a laser scanner, temperatures from an infrared radiation thermometer, and photos from nadir cameras. Within this period measuring flights for two campaigns, JuRaS and CHIRP were conducted (see Fig. 6.3.1). As the target areas of both projects overlap, there was also an overlap of the measuring time. Additional to the flights scheduled for the projects also two test flights were performed, to collect data for future reference with different measurement settings at the same location.

The installment of the scientific equipment took place at *Novo Airfield*, from where we also conducted the first test flight for calibration purposes and testing of the imaging mode of the radar. For this we chose a route across the ice shelf and along parts of the Potsdam Glacier close to the station. Unfortunately, low clouds prevented the completion of parts of the profile, covering the upper part of the glacier, and thus overlapping with ground-based measurements conducted by Anschütz et al. (2007).

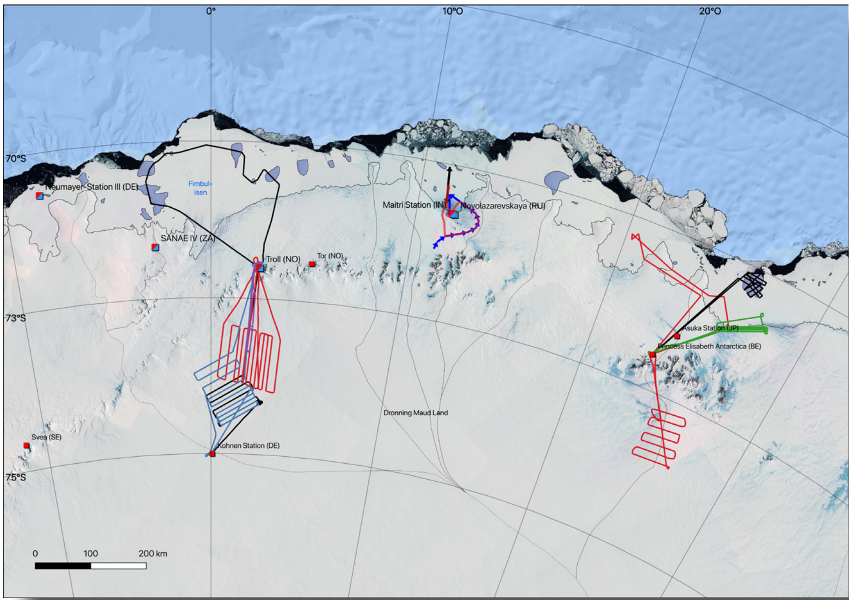

Fig. 6.3.1: Map of completed flight lines during the JuRaS and CHIRP campaigns

The main base for the planned JuRaS flights was *Troll Station*, where we stayed from 21.12.2018 until 3.1.2019. The survey area is located on the plateau between *Troll station* and *Kohnen Station*, and we used *Kohnen Station* as a fuel stop for some of the flights. Due to initial failure of parts of the radar hardware two profiles had to be repeated after installing the backup system.

For JuRaS the profiles consist of parallel lines directed perpendicular to the flow direction of the main trunk of the Jutulstraumen, as well as profiles across an eastern tributary. The originally planned profile distance of 15 km could be decreased to 7.5 km in most of the area, as low fuel consumption at high altitudes allowed for extension of the flight time. Due to our fueling stop in *Kohnen Station* we were also able to collect a connecting radar line between the location of the EDML ice core to our main survey area, which is useful for referencing and dating reflections in our data and making connections to survey flights conducted in the 1990s, 2000s and later.

In the eastern part of the survey area we performed an additional test flight, consisting of two parallel lines of 30 km length, which were measured with 6 different system settings in total. This test was very useful for the decision which mode to use for the CHIRP flights across the ice rises and the ice shelf.

From *Troll Station* we also conducted the first profile of the CHIRP campaign, a profile across the surrounding ice rises of the Fimbul Ice Shelf. In general, weather conditions were marginal over the ice shelves during most of our survey time due to the closeness to the coast.

The main base for the CHIRP flights was *Princess Elisabeth Station (PES)*, in the vicinity of the Roi Baudoin Ice Shelf, where the focus of the campaign was on melt channel evolution from grounded ice to the ice shelf as well as the ice rises surrounding the Ice shelf. A late arrival due to the weather condition shortened our survey time significantly, and we were only able to complete three of four planned flights across the ice shelf, before we had to leave for *Neumayer Station III*. During our stay at *PES* we performed one more measurement flight for JuRaS north of the station, as the weather did not allow for flying on the ice shelf at that time.

Preliminary results - JuRaS

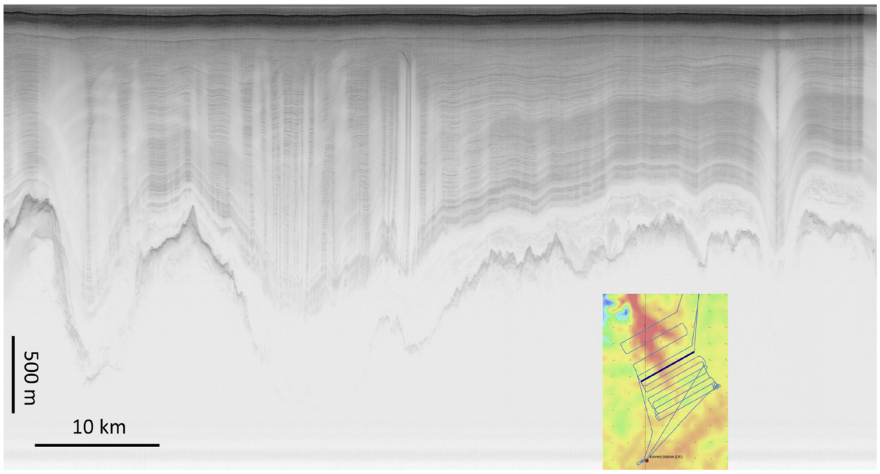

Fig. 6.3.2: Radar profile covering the main trunk of the Jutulstraumen. The inset shows the bedrock from the Bedmap 2 data set (Fretwell et al., 2013).

For most of the JuRaS radar lines there is a clear bedrock reflection, with exceptions in some of the deep troughs of the main trunk of the ice stream, where the signal is partly lost. The internal reflections are also well resolved, and the data show also events in the basal layer of the ice sheet, which was formerly termed as the “Echo-Free-Zone (EFZ)” (Drews et al., 2009) as it usually did not show any discernible reflective signatures above the noise level of the older radar systems. In most areas the undulations of the reflections is mainly controlled by the bedrock shape but there are exceptions, where they are drawn down towards the base, possibly indicating basal melting.

Regularly undulating internal reflection horizons seem to be present in the upper part of the ice sheet along some profiles. These structures somewhat resemble dune signatures observed elsewhere in Antarctica. They are possibly caused by an interplay of surface wind speed, surface slope and redistribution of snow. However, until further analysis this interpretation remains speculative.

Fig. 6.3.3 shows an example of the radar data south of PES, a region which previously has been covered poorly by airborne radar. The Bedmap data set for this region is mainly based on gravimetry, and thus not well resolved. Our data show the rugged terrain beneath the divide South of PES, where steep narrow valleys are very well captured in the basal reflection. The internal reflections show a different structure on either side of the divide, possibly reflecting a change of the local accumulation regime.

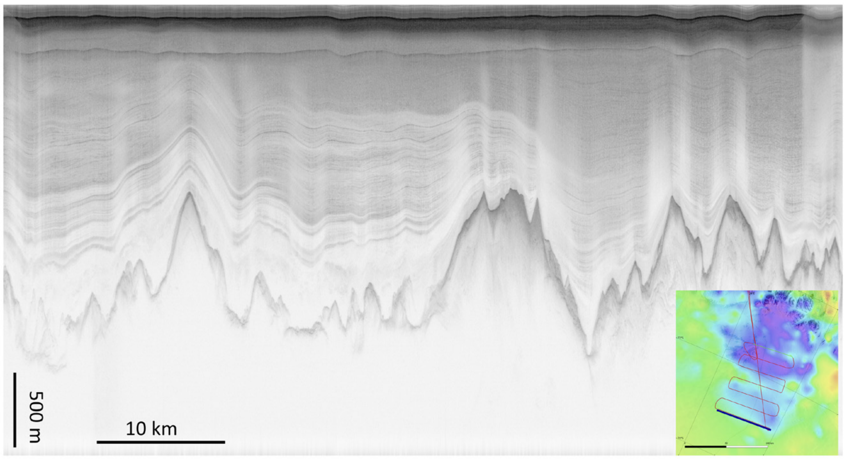

Fig. 6.3.3: Southernmost part of radar profile south of Princess Elisabeth Station in a region previously not covered by airborne radar. The inset shows the bedrock from the Bedmap 2 data set (Fretwell et al., 2013).

Preliminary results CHIRP

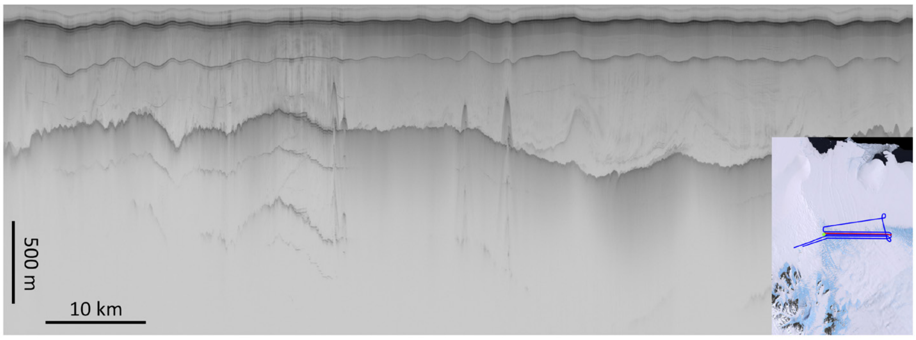

Fig. 6.3.4: Radar line just downstream of the grounding line of the Roi Baudoin Ice Shelf, showing several deep incisions of melt channels

The radar lines collected for the CHRIP campaigns were mainly flown over ice shelves and ice rises, covering areas with an ice thickness ranging from several hundreds to about 1,000 m. Here the multiple of the surface reflection is unfortunately a prominent feature, which has to be addressed by further processing. It was not possible to avoid this problem by adaption of the height above ground. However, internal layers could be mapped within the ice rises with the UWB broadband modus. The expected melt channels upstream of the grounding line of Roi Baudoin Ice Shelf are well resolved in the data and their evolution downstream could be documented as well.

Fig 6.3.4 shows several high-reflective events, with a diffractor-like geometry. Although they are about 30 - 50 % above the base of the ice in the areas surrounding these events, at this point we interpret them as reflections from subglacial melt channels, at the interface of ice and ocean, and not as intraglacial features like melt channels percolating from the ice surface. They are comparable to features observed in the vicinity of the grounding line at 79°N glacier (pers. comm. N. Dörr).

Acknowledgements

We thank the Polar 6 crew Will Wilson (captain), Chris Bracker (co-pilot), Eric Prager (aircraft engineer) and system engineers Martin Gehrmann and Sebastian Spelz for their dedicated support in the field. Moreover, we thank all stations (*PE, Troll, Novo* and *Neumayer Station III*) for the cordial support, which made these flights possible.

Data management

After full analyses the data will be made available in the World Data Center PANGAEA Data Publisher for Earth & Environmental Science (www.pangaea.de).

References

Alley R B, Clark P U, Huybrechts P, and Joughin I (2005). Ice-Sheet and Sea-Level Changes, Science, 310 (5747), 456-460.

Anschütz A, Eisen O, Oerter H, Steinhage D and Scheinert M (2007). Investigating small-scale variations of the recent accumulation rate in coastal Dronning Maud Land, East Antarctica, Annals of Glaciology, 46, 14-21.

Drews R, Eisen O, Weikusat I, Kipfstuhl S, Lambrecht A, Steinhage D, Wilhelms F, and Miller H (2009). Layer disturbances and the radio-echo free zone in ice sheets, The Cryosphere, 3, 195–203.

Fretwell et al., (2013). Bedmap 2: improved ice bed, surface and thickness datasets for Antarctica, The Cryosphere, 7, 375-393.

Joughin I, Smith B E, and Holland D M (2010). Sensitivity of 21st century sea level to ocean-induced thinning of Pine Island Glacier, Antarctica, Geophysical Research Letters, 37, L20502, doi:10.1029/2010GL044819.

APPENDIX

A.1 Teilnehmende Institute / Participating Institutes

A.2 Teilnehmer / Participants

A.3 Logistische Unterstützung, Überwinterer / Logistic support, wintering team

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College of Physics	College of Physics, Jilin University Changchun, 2699 Qianjin St. Changchun 130012 China
CSM	Centre Scientifique de Monaco Département de Biologie Polaire, Laboratoire International Associé 'BioSensib' (LIA 647 / CSM & CNRS-UniStra) 8, quai Antoine 1er, MC 98000 Monaco
CNRS	Institut Pluridisciplinaire Hubert Curien, CNRS – UMR 7178 23 rue du Loess BP 28, 67037 Strasbourg Cedex 2 France
DLR	Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR) Institute of Space Systems Robert-Hooke-Str. 7 28359 Bremen Germany
DNV GL	DNV GL Am Leuchtturm 10 27568 Bremerhaven Germany

	Address
DWD	Deutscher Wetterdienst Geschäftsbereich Wettervorhersage, Seeschifffahrtsberatung Bernhard Nocht Str. 76 20359 Hamburg Germany
FAU	Friedrich-Alexander-Universität Erlangen-Nürnberg Henkestraße 91 91052 Erlangen Germany
GFZ	Deutsches GeoForschungsZentrum GFZ Telegrafenberg 14473 Potsdam Germany
Helmholtz Association	Helmholtz Association Anna-Louisa-Karsch-Straße 2 10178 Berlin Germany
Humboldt-Uni. Berlin	Humboldt-Universität zu Berlin Unter den Linden 6 10117 Berlin Germany
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IPEV	Institut Polaire Français Paul-Emile Victor (IPEV) Technopôle Brest-Iroise CS 60 075 29280 Plouzané France
Pistenbully	Kässbohrer Geländefahrzeug AG Kässbohrerstraße 11 88471 Laupheim Germany
PRIC	Polar Research Center, Jilin University Changchun 130026 China

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ProSiebenSat.1 Digital	ProSiebenSat.1 Digital GmbH Medienallee 6 85774 Unterföhring Germany
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UF	University of Florida, Fifield Hall 2550 Hull Road PO Box 110690 Gainesville, Florida 32611 USA
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Uni Köln	Universität zu Köln Albertus-Magnus-Platz 50923 Köln Germany
Universität Oldenburg	Carl von Ossietzky Universität Oldenburg Ammerländer Heerstraße 114-118 26129 Oldenburg Germany
Univ. Strasbourg	École doctorale des Sciences de la Vie et de la Santé CDE - 46 Bd de la Victoire 67000 Strasbourg France

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A.2 EXPEDITIONSTEILNEHMER / EXPEDITION PARTICIPANTS

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Arndt	Stefanie	AWI	Scientist	Sea Ice Physics
Bagheri-Dastgerdi	Saeid	AWI	PhD student	Paleo-climate Dynamics
Beck	Lisa	INAR	PhD student	Atmospheric Sciences
Berger	Sophie	AWI	Scientist	Glaciology
Boetius	Antje	AWI	Director	Visitor
Dallmayr	Remi	AWI	PhD student	Glaciology
Della Lunga	Damiano	AWI	Scientist	Glaciology
Dorn	Markus	DLR	Scientist	Biology
Dummann	Wolf	Uni Köln	Scientist	Geology
Eagles	Graeme	AWI	Scientist	Geophysics
Eilers	Jörg	AWI	Administration	Visitor
Eisen	Olaf	AWI	Scientist	Glaciology
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Fabry	Ben	FAU	Scientist	Biophysics
Ferl	Robert	UF	Scientist	Biology
Franke	Steven	AWI	PhD student	Glaciology
Freitag	Johannes	AWI	Scientist	Glaciology
Fromm	Tanja	AWI	Scientist	Geophysics
Gong	Da	PRIC, College of Physics	Scientist	Coring Engineer
Grasse	Torsten	BGR	Technician	Geophysics
Gromig	Raphael	AWI	Scientist	Marine Geology
Grote	Sebastian	AWI	Media Support	Visitor
Haas	Christian	AWI	Scientist	Sea Ice Physics
Heitland	Tim	AWI	Physician	Logistics
Hilmarsson	Sverrir	Freelance	Technician	Logistics
Hoffmann	Mathias	BGR	Technician	Geophysics
Hörhold	Maria	AWI	Scientist	Glaciology
Houstin	Aymeric	CSM/ Univ. Strasbourg	PhD student	Biology
Hüther	Matthias	AWI	Technician	Glaciology
Irvin	Anne	YU	Scientist	Geoscience
Jansen	Daniela	AWI	Scientist	Glaciology
Kipfstuhl	Sepp	AWI	Scientist	Glaciology
Köhler	Peter	AWI	Technician	Logistics
Krüger	Kontantin	AWI	Student	Meteorology
Laepple	Thomas	AWI	Scientist	Geoscience
Le Bohec	Céline	CNRS, CMS, IPEV	Scientist	Biology
Paul	Anna-Lisa	UF	Scientist	Biology

Name/ Last name	**Vorname/ First name**	**Institut/ Institute**	**Beruf/ Profession**	**Fachrichtung / Discipline**
Nixdorf	Uwe	AWI	Vice Director	Visitor
Rex	Markus	AWI	Scientist	Physics
Ritter	Oliver	GFZ	Scientist	Geophysics
Rohde	Jan	AWI	Engineer	Sea Ice Physics
Römpler	Oliver	AWI	Technician	Scientific Workshop
Ruholl	Christoph	AWI	Administration	Visitor
Schmithüsen	Holger	AWI	Scientist	Meteorology
Schubert	Daniel	DLR	Scientist	Aerospace Engineering
Sipilä	Mikko	INAR	Scientist	Air Chemistry
Smith	Emma	AWI	Scientist	Glaciology
Stahn	Alexander	University of Pennsylvania, Charité	Physician	Medical Science in Psychiatry
Strelow	Giesela	AWI	Technician	Visitor
Ungermann	Carlo	AWI	Administration	Visitor
Vrakking	Vincent	DLR	Scientist	Aerospace Engineering
Wahl	Sonja	University of Bergen	PhD student	Geoscience
Weckmann	Ute	GFZ	Scientist	Geophysics
Weller	Rolf	AWI	Scientist	Air Chemistry
Wiestler	Otmar	Helmholtz Association	President Helmholtz Association	Visitor
Yazhou	Li	PRIC	PhD student	Coring Engineer
Zabel	Paul	DLR	Scientist	Aerospace Engineering
Zeidler	Conrad	DLR	Scientist	Industrial Engineering
Zitterbart	Daniel	FAU, WHOI	Scientist	Biophysics
Zwicker	Sarah	AWI, Universität Oldenburg	Student	Biology

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

Name/ Last name	**Vorname/ First name**	**Institut/ Institute**	**Beruf/ Profession**	**Fachrichtung / Discipline**
Czerwonka	Mirco	AWI	Scientist	Wintering Team 2018
Denecke	Mirko	RFL	Technician	Logistics
Eder	Pitt	RFL	Technician	Logistics
Ferstl	Katharina	AWI	Scientist	Wintering Team 2018
Fontes	René Pascal	RFL	Engineer	Logistics
Gehrmann	Martin	AWI	Technician	Logistics
Giese	Ole	RFL	Technician	Logistics
Gonser	Matthias	ProSiebenSat.1 Digital	Editor	TV, Galileo
Gropp	Bernhard	AWI	Physician	Wintering Team 2018
Heuck	Hinnerk	RFL	Technician	Logistics
Hoffmann	Helene	AWI	Scientist	Wintering Team 2018
Ilg	Patrick	Freelance	Cameraman	TV, Galileo
Kenny	Darragh	AWI	Student	Meteorology
Koch	Michael	AWI	Scientist	Wintering Team 2019
Kohlberg	Eberhard	AWI	Physician	Logistics
Köhler	Jens	RFL	Technician	Logistics
Korger	Edith	AWI	Scientist	Wintering Team 2019
Krams	Ralf	Pistenbully	Technician	Pistenbully Maintenance
Laubach	Hannes	RFL	Technician	Logistics
Leitl	Martin	RFL	Physician	Logistics
Lemburg	Johannes	AWI	Technician	Logistics
Maasch	Matthias	AWI	Technician	Wintering Team 2018
Marquardt	Geron	RFL	Cook	Logistics
Miesch	Frank	DNV GL	Inspector	Safety
Mitteregger	Christian	RFL	Technician	Logistics
Müller	Hanno	AWI	Scientist	Wintering Team 2018
Müller	Andreas	AWI	Technician	Wintering Team 2019
Naundorf	Katharina	AWI	Cook	Wintering Team 2019
Paulmann	Christian	DWD	Forecaster	Flight Weather Forecast
Peter	Dirk	RFL	Cook	Logistics
Peters	Nils	AWI	Technician	Wintering Team 2019
Petersen	Christoph	AWI	Technician	Logistics
Reich	Stefan	RFL	Technician	Logistics
Reick	Julia	AWI	Cook	Wintering Team 2018
Riess	Felix	RFL	Inspector	Logistics
Rohkohl	Dorian	RFL	Technician	Logistics
Sans Coll	Cristina	AWI	Engineer	Logistics
Schad	Thomas	AWI	Technician	Wintering Team 2019

Name/ Last name	Vorname/ First name	Institut/ Institute	Beruf/ Profession	Fachrichtung / Discipline
Schubert	Holger	RFL	Technician	Logistics
Schumacher	Marcus	AWI	Scientist	Wintering Team 2019
Spelz	Sebastian	AWI	Technician	Logistics
Stakemann	Josefine	AWI	Scientist	Wintering Team 2019
Steckelberg	Birgit	AWI	Physician	Wintering Team 2019
Sterbenz	Thomas	AWI	Technician	Wintering Team 2018
Strahl	Gaby	RFL	Administration	Housekeeping
Trimborn	Klaus	Freelance	Technician	Logistics
Ulbort	Marlon	AWI	Electrician	Wintering Team 2018
Weigand	Gerhard	RFL	Physician	Logistics
Zahlauer	Holger	RFL	Technician	Logistics

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