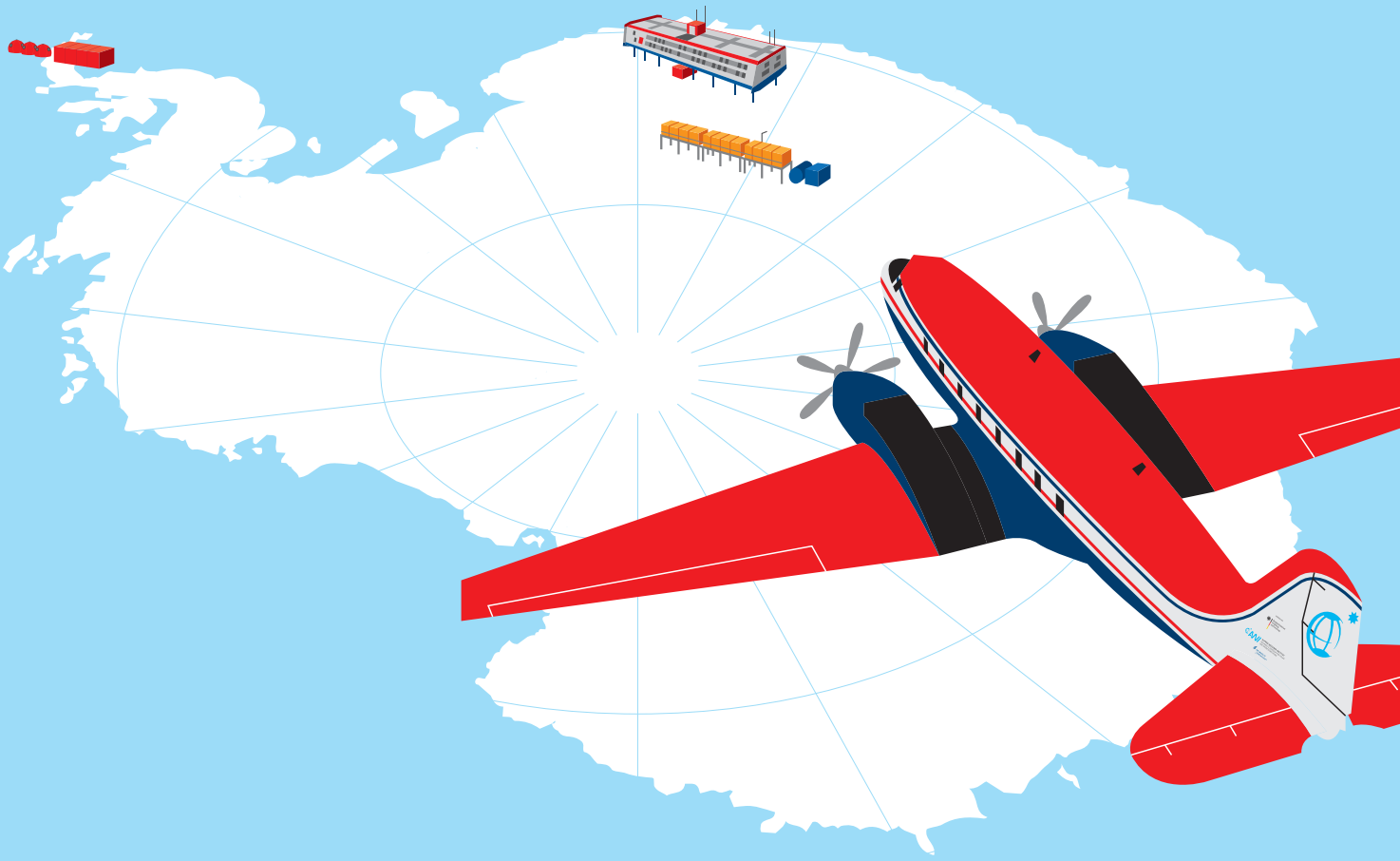
ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

Expedition Program

ANTARCTICA

(ANT - Land 2021/22)

Land activities & flight missions



HELMHOLTZ

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1. ANT-LAND 2021/22

1.1 Summary

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The still ongoing pandemic situation influences the Antarctic land activities in season 2021/22. To achieve the main goal, to keep Antarctica virus free and support science as good as possible, the

number of inbound flights to Antarctica was reduced to a maximum of three intercontinental flights. All expeditioners had to be in a 14-day quarantine prior to their deployment to Antarctica. Due to strict measures, we will be able to conduct several science projects and perform the maintenance of the station to prepare it for the next winter. The 43. wintering team will join the summer campaign mid of January 2022 to take over NEUMAYER STATION III from their predecessors. The supply of the station will be performed by MV MALIK ARCTICA with a planned call the Atka Bay after Christmas. RV POLARSTERN will be expected to call at Atka Bay in March 2022.

This season, KOHNEN STATION will be opened from end of November 2021 until end of January 2022. Along the traverse route from NEUMAYER STATION III to KOHNEN STATION, the project "Kottaspegel" is measured and two smaller projects will take place at KOHNEN STATION, once the station is open. Additionally, a team of technicians will maintain the station and the scientific trench.

1.3 Scientific projects at NEUMAYER STATION III

The maintenance of the observatories will be done by the supervisors. The yearly routine covers the lifting of the instruments due to snow accumulation during the year and maintenance of the instruments to ensure the continuity of the measurement series.
Meteorological Observatory – Holger Schmithüsen (AWI)
Air chemistry Observatory – Rolf Weller (AWI)
Geophysical Observatory – Vera Schlindwein, Tanja Fromm, Jölund Asseng (AWI)
CTBTO – I27DE – Mathias Hoffmann, Torsten Grasse (BGR, Germany)

Wintering Projects:
AFIN
PI: Stefanie Arndt (AWI)
Continuous observations of sea ice fastened to coasts, icebergs and ice shelves is of crucial importance for understanding key processes and predicting changes in the climate- and ecosystem in the polar regions. Near Antarctic ice shelves, this landfast sea ice exhibits two unique characteristics that distinguish it from most other sea ice: On the one hand, ice platelets form and grow in super-cooled water, which originates from ice shelf cavities. The crystals accumulate beneath the solid sea-ice cover and are incorporated into the sea-ice fabric, contributing between 10 and 60% to the mass of the land-fast sea ice around Antarctica. On the other hand, a thick and partly multi-year snow cover accumulates on the fast ice, altering the sea-ice surface and affecting the sea-ice energy and mass balance. In order to investigate the role and the spatial and temporal variability of platelet ice and snow for Antarctic fast ice, we perform regular field measurements on the land-fast sea ice of Atka Bay since 2010 as part of the international Antarctic Fast Ice Network (AFIN).

CHOICE
PI: Alexander Choukér (University of Munich)
Knowledge achieved from CHOICE I&II (Antarctica) and from more "technical" isolation environments (such as MARS500) as well as from the International Space Station (ISS), has helped to elucidate the link between an exposure and a potential disorder in the area of immune dysfunctions. This provides insights and tentative interactions into the interconnected mechanisms of intrinsic and extrinsic regulatory effects of the immune system. The first results have provided i) first clinical observations showing initial higher rate of infections, ii) genetic transcriptome pattern to be systematically affected, iii) delayed but continuously increased in vitro hypersensitivity especially to fungal antigens as well as

iv) viral reactivation altogether in a microbiologically changing environment.
This altogether is leading to the questions of their interactions and the leading impact. Especially since case reports from the medical staff and from overwintering crew members in Antarctic bases report of emerging allergies and the occurrence of anaphylactic incidences, exploring how sensitivity reactions are triggered during isolation is required. Furthermore the interlinkage to the environmental load, its extrinsic and intrinsic dynamics (e.g. the Microbiome) and to viral activity and the hormonal control in the overwintering crew has to be elucidated. Moreover, the factor of exposition time seems also a strong variable and needs to be addressed in a controlled way in the same environment, resulting in a summer campaign element and an overwintering crew element. This especially since our observations and assumptions are complimentary to data from ISS in Space and returning crew. Biologicial specimen will be collected and complimentary to the protocol at Concordia Station Dome C (DC), pre, at early arrival, at start of confinement, twice during confinement (April and July), post-winter opening, before leaving station, at arrival in South Africa (Tbd) and after longer "re-exposition" in Europe. Samples are collected along the approved ethical board protocol and will included blood, usine, salvia, stool and hair and are complemented by questionnaires/tests addressing well-being and emotional memories.

EDEN-ISS

PI: Daniel Schubert (DLR, Germany)

The EDEN ISS project was funded by the European Union Horizon 2020 project (reference number: 636501) supported via the COMPET-07-2014 - Space exploration – Life support subprogramme. The project has developed and has subsequently deployed an advanced plant production system to the NEUMAYER STATION III Antarctic station in the summer season 2017/18. The EDEN ISS greenhouse container was operated for a full winter season at the analogue test site in Antarctica (NEUMAYER STATION III). The production of fresh food for the overwintering crew was successful and more than 140 kg of lettuce, cucumber, radish, tomatoes, and herbs have been harvested until end of the winter season. Scientific investigations on microbial behaviour within the grow chamber, biomass quality examinations, and operation procedure testing were also performed. In the season 2018/19 several systems in the container will be upgraded and repaired. The greenhouse will be operated by the overwintering team of the NEUMAYER STATION III and supported by the EDEN team in the mission control room at DLR Bremen. In addition to the production of fresh food for the crew on site several scientific questions regarding remote operations of a greenhouse in extreme environments will be investigated.
This project ends, the facility will be shut down in this season and dismantled in season 2022/23.

ISOAnt

PI: Martin Werner (AWI)

This proposal is linked to the REKLIM-Project „Iso-Ant", which will improve our knowledge and understanding of the hydrological cycle and its isotopic composition in Antarctica. Here, we apply for using the facilities at NEUMAYER STATION III to perform maintenance work on a laser-based spectrometer for isotope analyses. This projects ends and the instrument will be dismantled during this season.

MICA-S

PI: Khan-Hyuk Kim (Kyung Hee University, South Korea)

The goal of this project is to develop and install an induction-coil magnetometer at NEUMAYER STATION III for the studies of ultra low frequency (ULF) waves associated with solar wind coupling to the magnetosphere and ionosphere. Observation of geomagnetic fields is critical in understanding the physical link between the Sun and the Earth's magnetosphere and ionosphere.

MIMO-EIS

PI: Olaf Eisen (AWI)

The interaction of ice shelves with the ocean water underneath is one of the key processes for the future development of ice masses. Especially for the Antarctic ice sheet, mass loss through ice shelves is the dominant component of loss in the mass budget. Water masses entering the Filchner-Ronne Ice Shelf system are partly pre-conditioned in the coastal current of Dronning Maud Land, Antarctia. This project aims at establishing a continuous monitoring system on the Ekström Ice Shelf (EIS) to determine the interannual (and potentially seasonal) variability of basal melt rates to improve our understanding of the processes of ice-ocean interaction along the DML coast. To this end, an Autonomous phase-sensitive Radio-Echo Sonding (ApRES) system in the center of EIS will be operated, at the flank of the main bathymetric trough. Data will be retrieved half-annually and will be used as validating constraints in numerical ocean-modelling runs as well as satellite-based analyses. The project will extend a chain of already available and ongoing ApRES observations on other ice shelves in the Dronning Maud Land Region, like Roi Baudouin and Fimbul, and thus increase our observational and potentially monitoring capabilities in this region.
The interaction of ice shelves with the ocean water underneath is one of the key processes for the future development of ice masses ice sheets. Especially for the Antarctic ice sheet, mass loss through ice shelves is the dominant component of loss in the mass budget. Under steady-state conditions, this mass loss is balanced by an equal amount of mass deposition on the ice sheet. Although mass loss from ice shelves does not directly contribute to a change in sea level (as they are already floating), their socalled buttressing effect is of important for the dynamic behaviour of the ice streams and sheet upstream of the grounding line. Over the last decade it turned out that the presence of warmer waters at and underneath ice shelves and tidewater glaciers can lead to a massive increase in basal melt rates (e.g. Milillo et al., 2019). Subsequently, the ice shelf can react dynamically, and with reduced buttressing the mass flux across the grounding line will increase – providing a net mass gain to the ocean.
Based on numerical modelling under warming climate scenarios, it is likely that the Filchner-Ronne ice shelf, one of the three largest ice shelf systems on Earth, will potentially be subject to a considerable increase in basal melt rates in the second half of this century, induced by warmer ocean water entering the ice shelf cavity (Hellmer et al., 2012). For this process, the pre-conditioning of water masses in the coastal current of Dronning Maud Land, Antarctica, is potentially important. Previous studies investigated the ocean process in the cavity of other ice shelves along the DML coast (e.g. Hattermann et al., 2012) and also their effect on and interaction with ice-shelf basal melting.
Dedicated observations of basal melt rates are nowadays routinely facilitated by application of phase sensitive Radio-Echo Sonding (pRES). Deploying pRES repeatedly at the same position over longer periods (weeks, months) provides integrated observations, from which the mean basal melt rate can be reproduced. The pRES system can also operate in an unattended mode, basically autonomously, as so-called ApRES. In that case, the observations take place on the order of minutes to hours. This provides a time series of basal processes, which enables the resolution of ice-ocean interaction on the temporal scale relevant for tidal action as well as seasonal changes. Lindbäck et al. (2019) deployed ApRES on Nivlisen and observed strong variations of basal melt rates over days and weeks, related to the overall atmospheric circulation and sea-ice pattern, which changed ocean properties in the cavity. Previous results from the Roi Baudoin ice shelf based on satellite measurements (Berger et al., 2017)

Neuromayer

PI: Alexander Stahn (Charité Berlin, Germany), Alexander Choukér (LUM Munich, Germany)

We will investigate both immediate and long-term benefits of *Hybrid Training*. Our primary outcomes are neurostructural and neurofunctional changes assessed with magnetic resonance imaging (MRI), and cognitive performance assessed with classical paradigms, but also operationally relevant tasks (i.e. virtual ISS robotic arm docking task). We will also assess biochemical markers of stress and neuroplasticity, objective measures of sleep-wake rhythmicity and sleep structure, subjective symptom reports, and group cohesion with unobtrusive measurements as additional outcomes that will provide insights into mechanisms and consequences of the observed structural and functional brain changes, and their reversibility by *Hybrid Training*. These data will be compared to historic controls from NEUMAYER STATION III and other Antarctic stations (Concordia, Halley), space analog environments and the ISS. At the end of the project, we will have a much clearer understanding whether and to what extent

the detrimental effects of ICE environments on neuroplasticity and behavioral health can be mitigated by *Hybrid Training*.

PALAOA

PI: Olaf Boebel (AWI)

Recording the underwater calls of marine mammals is one of the most promising methods to study distribution and seasonal migration of these animals in the ice-covered Antarctic. Visual sightings of marine mammals in Antarctic waters are rare since human access is limited and animals only occasionally surface to breathe. Acoustic recordings, on the other hand, can be made year round. By means of the PALAOA observatory, ocean acoustics experts from the Alfred Wegener Institute for Polar and Marine Research in the Helmholtz Association have discovered that leopard and Ross seals populate Antarctic waters near NEUMAYER STATION III.

P.S.I. (Performance and Stress in Isolation)

PI: Alessandro Alcibiade (University of Pisa)

In order to increase our database we propose performing at the Neumayer station the same research we are performing at Concordia Station in agreement with the ESA Human and Robotic Exploration Directorate (P.O.C Dr. Ngo Ann and Dr. Harrods).

Background: A large variety of studies in the scientific literature suggest the existence of a correlation between changes in the amplitude and frequency of the words spectrum, and the stress levels perceived in the test subjects.

Objectives: This study aims to quantify the correlation between the change in length and variation in the structur of a written text and the psychological and perceived stress levels in the writer, determined through a Psychological questionnaire and through the analysis of the peculiar chanches in the complexity and variety of the writtend composition.

Experimental design: The experiment will be performed by subjects experiencing voluntary isolation during the winter-over period at Neumayer Antactic Station. The experiment consists of two tasks.

1st task: *Text.*

The written texts will be acquired analyzing the periodical reports that key crew-members (ex. Station Leader, MD, etc.) will have to provide timely to their mainland agency during the whole winter over period.

2nd Task: *Short psychological questionnaire***,** to be completed at the end of the winter-over isolation from that key crew-members involved.

Ethic: The content of the text will not be considered but only the structure, all the data will be reported anonymized. This experiment has the ethic approval from Universitá di Pisa and the scientific commission of Concordia, and need to be extended to Neumayer III to gain key comparison data.

SPOT

PI: Daniel Zitterbart (WHIO, USA & University of Erlangen, Germany), Ben Fabry (university of Erlangen, Germany)

This project aims to understand the reorganization process in penguin huddles and the implications for social thermoregulation. We will install a remote-operated penguin observatory including hard- and software for fast image acquisition and real-time processing. The observatory will be capable of detecting the whole huddle, as well as tracking the movements of thousands of individual penguins throughout the winter. An accurate count of animals within the colony and the size of individual animals will also be recorded, and together our data will help to estimate how the increasing environmental strain such as ongoing climate changes, thinning sea ice and reduced krill availability, is affecting Emperor penguins.

WSPR

PI: Ulrich Walter (TU Munich, Germany), Michael Hartje (HS Bremen, Germany)

Using a permanent radio beacon at NEUMAYER STATION III, in order to investigate the state of the D- E- and F-layers of the terrestrial ionosphere and their influence on radio wave propagation throughout the communication spectrum.

This refers to terrestrial paths on shortwave as well as to satellite communication, where radio signals have to penetrate the ionospheric layers in order to reach ground stations.

Seasonal Projects:

VACCINE (Variation in Antarctic cloud condensation nuclei (CCN) and ice nucleating particle (INP) concentrations at Neumayer Station

PI: Silvia Henning, Frank Stratmann (TROPOS, Leipzig, Germany)

It is a great challenge to assign exact numbers to the human influence on climate change. While we know the effect of carbon dioxide emissions quite well, there are anthropogenic emissions of other substances that effect climate through complex chains of interactions with atmospheric processes, that are not yet well characterized (IPCC,2013). This lack of knowledge causes uncertainties in the quantification of how human activities influence weather and climate (Carslaw et al. 2013). To identify the anthropogenic effects, we need to characterize the atmosphere as it was before industrialization. The fact that Antarctica is geographically isolated from anthropogenic emissions makes it a perfect place to study pristine conditions (Hamilton et al., 2014). In this project we, i.e., TROPOS suggests to extend the existing aerosol measurements at Neumayer station by in-situ cloud condensation (CCN) and ice nucleating particles (INP) measurements. These data will be linked with meteorological information (e.g. back trajectories) and information on the chemical composition of the sampled aerosol particles for identifying sources of INP and CCN. The quantitative information on Antarctic Pristine CCN and INP will be made availed on the PANGAEA Database and thereby be useable to evaluate and constrain global models and satellite retrieval methods.

This project will end this season and the instrument is dismantled.

ReMeltRadar

PI: Reinhard Drews (University of Tübingen, Germany)

The Antarctic ice sheet is acutely sensitive to interactions with its surrounding ocean. Ocean-induced melting at the grounding line (the boundary between the grounded ice sheet and the floating ice shelves) has the potential to cause irreversible ice-sheet mass loss. Intrusion of warm waters into ice-shelf cavities thereby sensitively depends on the presence or absence of deep basal troughs, and also on local circulation patterns that develop in response to multiple processes such as fresh-water input, sea-ice formation or ice accretion. This complexity combined with sparse data make it notoriously difficult to predict which catchments are vulnerable to ocean melting. Consequently, the ice and ocean communities have joined forces to replace crude parameterizations with physical processes. However, observational constraints for validation will be critical. Previous research near Neumayer (incl. radar sounding, seismic surveying and CTD profiling) makes the Ekstömisen a unique candidate for a reference ice shelf for the large number of small ice shelves in East Antarctica where many of the key processes of ice-ocean interactions can be understood. We propose a novel approach using the internal ice-shelf stratigraphy as an ice-dynamic, atmospheric, and most importantly oceanographic archive from which ocean melting can be inferred over centennial-millennial time scales. Near Neumayer, the internal radar stratigraphy is exceptionally covered by dense airborne radar surveys. A re-evaluation of this dataset will provide internal surfaces required for the inversion with an already established ice-flow model. The main target of field work is the collection of ground-control profiles using a coherent depth-sounding radar (ApRES) that can determine relative thickness changes (and hence melt rates) within

mm using a Vernier technique. Going beyond previous efforts where this has been demonstrated at selected points, we will combine the ApRES with an autonomous robot that is steered by a real-time kinematic GPS. Repeat surveys will result in 2D profiles of basal melt rates (and vertical velocities incl. firn densification) acting as constraints for the inversion. A secondary objective is the determination of ice rheology using radar polarimetry to infer ice-fabric depth profiles using birefringence and anisotropic characteristics of wave propagation and backscatter. This has never been done in 2D and also not on ice shelves, but may provide critical insights for ice rheology contributing to the buttressing of grounded ice by ice shelves. Thirdly, the phase coherence and accurate positioning will allow to apply synthetic aperture radar processing techniques significantly increasing the along-track resolution to image spatially small features such as basal terraces (possibly hot spots of melting) and pinning points (locally grounded features pinning the ice-shelf upfront). A successful deployment of our novel robotic radar system in a controlled environment will deliver the proof-of-concept for a novel acquisition technique, that will provide the sorely required data to understand the full complexity of ice-ocean interactions. In combination with the already available data on that ice shelf, this will be the next step forward to extend our knowledge about ice-shelf processes, using the Ekströmisen as a reference ice shelf for the internationally coordinated coupling of ice and ocean models.

GrouZE

PI: Tanja Fromm (AWI)

Antarctica's ice shelves are the main drain for mass loss of the ice sheet and the interface to the ocean. A major control of this process are ice-ocean interaction. Tides are the most direct forces acting on the ice shelves, inducing vertical and horizontal motion and a recent study revealed a strong impact of tides on the ice flow rates at the Ekstroem Ice shelf (Fromm et al, in prep). The northward flow of the ice stream is mainly modulated with 3 and 4 cpd (cycles per day), whereas the dominant vertical tides have a periodicity of 1 and 2 cpd and 10 times larger amplitudes than the 3 and 4cpd tides. Particularly the causes of the higher frequency tidal modulations are still poorly understood and observational constrains are sparse. During tide induced grounding line migration a thin water layer forms beneath the ice, friction becomes important for the tides and could cause the observed high harmonic tidal constituents. The thin water layer reduces basal drag between the ice and the bedrock and such enhances the ice flow.
We propose to investigate these ice dynamic processes with a geophysical / geodetic study of an exemplary region of the grounding zone of the Ekstroem-Shelf ice. We intend to capture vertical and horizontal motions of the ice using GNSS stations along the ice flow direction, from the freely floating ice shelf to permanently grounded ice. A seismological network will allow us to locate icequake activity from sticky spots at the ice-bed interface, which act as pinning points within the ice. With the magnetotelluric method (MT) we can image the sub-ice ocean-land transition and the crustal structure beneath. Another objective is to estimate the volume of highly conductive sea water beneath the resistive grounded ice and to test for possible temporal variations related to tidal motion.
The objectives of this project are in line with the already planned glaciological project ReMeltRadar which targets the same area around the grounding zone to estimate basal melt rates, ice rheology and local bed topography. Integrating the results of these two projects with previous research at Neumayer and the Ekstroem Ice shelf has the potential to establish the Ekstroem Ice shelf as a reference for small ice shelves in East Antarctica and to reveal key processes in ice-ocean interaction.

MT_ANT3

PI: Oliver Ritter (GFZ Potsdam, Germany)

Magnetotellurics (MT) is a 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 seismology, gravity, and magnetics. MT has very low environmental impact as only naturally

occurring electromagnetic (EM) field variations are measured at Earth's surface with reusable and re-deployable sensors. The main outcome of MT is the (3D) electrical conductivity distribution of the subsurface.
Electrical conductivity is an important physical parameter to identify properties of rocks and, perhaps more importantly, constituents within, such as fluids or mineralization. The electrical conductivity of fluids, for example, depends strongly on their salinity and temperature: Seawater is highly conductive (~0.3 Ohmm), while snow and ice are typically very resistive materials (~100,000 Ohmm). Methods to detect and image fluid inclusions at depth are important for the Polar Regions as subglacial water at the base of grounded ice sheets has significant effects on ice flow rates and basal friction (e.g. Recovery Glacier). In general, MT is more suitable for sub-ice imaging as the highly resistive ice cover hardly attenuates electromagnetic (EM) fields.
The unique conditions of Antarctica, which is largely covered with ice cause technical issues, particularly with the electric field recordings, as highly resistive snow and ice at surface of Antarctica hampers contact of the E-field sensors (telluric electrodes) with the ground. To address this principal problem we propose to test new and modified MT equipment of the Geophysical Instrument Pool Potsdam (GIPP) in the vicinity of the Neumayer Station III (NMIII) on the Ekström Ice Shelf and, if feasible, the Kohnen area, Antarctica. This new deployment is a follow-on project of preliminary work which could demonstrate general feasibility of the MT method but also high noise levels on the electric field recordings at higher frequencies.

SLIFT

PI: Sepp Kipfstuhl (AWI)

Neumayer Station III (~2300 to) is build on 16 legs each standing on a platform ~12 m^2 in area. Each year Neumayer is lifted two times, in total between 2 to 3 m, but settles over the year by ~1 m. The effevtive lifting is only ~1.5m. Presently cold, sintered firm from ~6 m below the surface (about -8°C) is filled underneath the legs. Some of the platforms the legs are resting on or even the legs themselves begin to tilt (up to more than 2°)
Important to reduce settling under load is:

1. That the density of snow used at the time of filling is as high as possible (porosity as low as possible)
2. That the snow underneath has a grain size distribution as broad as possible (0.1mm to 2 mm or so), and
3. That it's temperature is as high as possible so that the snows assumes as rapid as possible it's maximum compressive strength

This proposal tries to obtain a better understanding of the snow mechanics under the legs, e.g. why and how tilting occurs, why the station settles almost 40% during a year and whether it is possible to process the snow filled underneath the legs in such a way that the number of lifting operations can be reduced.
Samples from the processed snow used for filling and snow or firn cores taken into the compacted snow underneath the legs are planned to be analysed for density and microstructural properties at Neumayer Station and the cold laboratories at AWI in Bremerhaven.

MARE

PI: Celine LeBohec (CNRS-CSM-IPEV, France) & Daniel Zitterbart (Woods Hole Oceanographic Institution, USA)

MARE will assess the vulnerability of Antarctic ecosystems using the Emperor penguin as sentinel species. To evaluate the overall trend of a species and its adaptive capacities, it is crucial to long-term monitor more than one population, breeding in different ecosystems, and under consideration of high

risk of extinction in a near future according to climatic scenarii. This Life Observatory of emperor penguins (since 2017) 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 systems. As umbrella species, seabirds can play an important role in determining the size for Marine Protected Areas (MPAs), and help to map marine biological hotspots. Knowledge of the distribution at sea and foraging strategies of emperor penguins is extremely scarce. We aim to fill this gap 1) by biologging of birds from Atka Bay colony (TDR/GPS/ARGOS/Video/Audio) at different stages of their life cycle, and over regular intervals (e.g. 5 years), and 2) through collection of guano and stomach content (dead chicks) to determine the geologic provenance of the gastroliths gathered on the sea floor, the diet and trophic level (and its variability) on which they are foraging. Stomach and guano samples will also be used for pollution (microplastics, contaminants) and epidemiology studies.

DML_GIA

PI: Mirko Scheinert (Technical University of Dresden, Germany)

We aim to determine the deformation of the Earth's crust in Dronning Maud Land (DML) resulting from the instantaneous elastic response and glacial-isostatic adjustment (GIA) of the solid Earth to present and past ice-mass changes. GIA still exerts the greatest uncertainty when determining the mass balance of the Antarctic Ice Sheet by satellite gravimetry. The only direct measurement of GIA can be obtained by realizing geodetic GNSS measurements on bedrock. DML is one of the areas where comparably small deformation signals are expected but measured so far by only a few geodetic GNSS sites. We already started in 1995 to perform campaign-style GNSS measurements in DML, and continued them mostly between 2001 and 2005. Most of the sites are situated in the mountain ranges that run parallel to the coast in a distance of 100 to 200 km between 13°W to 14°E. Repeating these measurements we aim to determine the deformation pattern with an improved spatial resolution and over a long time span of partly more than 20 years. The inferred vertical deformation rates will serve as constraints for an improved GIA estimation, which will be done in two ways: Firstly, satellite altimetry and gravimetry will be combined to empirically estimate ice-mass balance and GIA. Secondly, the 3D rheological structure of the Earth will be revised and, subsequently, introduced to predict the GIA effect.

GNSS-RR

PI: Olaf Eisen & Ladina Steiner (AWI)

Antarctic mass balance changes contribute significantly to global sea level rise with an increasing negative trend in the recent decades. The total mass balance is mainly determined by ice discharge and surface mass balance (SMB). Following the climate warming, Antarctic SMB is expected to increase during future decades. The proposed study aims at developing a methodology for deriving automated and continuous specific SMB time series for fast moving parts of ice sheets and shelves (>10m/a) by an accurate and simultaneous estimation of continuous in-situ snow density, snow water equivalent, and snow deposition and erosion, averaged over an area of several square metres. A combined Global Navigation Satellite Systems remote sensing (GNSS RS) approach based on in-situ refracted and reflected GNSS signals will be developed and thoroughly evaluated regarding its applicability on a moving, high latitude ice sheet. The newly developed combined GNSS reflecto-/refractometry RS approach is expected to improve SMB estimates of polar ice sheets, ice streams, and glaciers due to the simultaneous, continuous, and accurate quantification of snow density, SWE, and snow deposition and erosion with a high temporal resolution, independent on weather conditions. Regional climate models, snow modeling, and RS data products will eventually profit from calibration and validation based on the derived field measurements, once such sensors can be deployed on larger scales.

1.4 Scientific projects at KOHNEN STATION

Kottaspegel

PI: Olaf Eisen (AWI)

The surface mass balance of East Antarctica has been increasing over the last decades, counteracting sea level rise through mass loss in mainly in West Antarctica. The Kottaspegel field campaigns shall continue measurements of annual surface snow mass balance and density along a stake line from Neumayer III via Kottas to Kohnen station to provide reliable ground-truth data or the specific surface mass balance. The measurements should be carried out on an annual to biannual basis along the bamboo stake line between Neumayer III and Kottas camp, and annual to at least tri-annual intervals from Kottas to Kohnen station. To allow a reliable connection to measurements in case of multi-year gaps, a shallow ground-penetrating radar survey and firn coring is optionally considered in some years. Short 1 meter snow cores shall be taken at each overnight-stop of the traverse to determine snow density. The quasi long-term observatory Kottaspegel has been in operation since the end of the 90s, with gaps between 2006 and 2014. Together with the monthly snow accumulation and regular density measurements at Neumayer III this will provide a comprehensive time series of the spatio-temporal longer-term development of the specific surface mass balance in this sector of Antarctica.

AWS-Kohnen

PI: Holger Schmithüsen (AWI)

The currently installed automatic weather station at Kohnen owned by IMAU cannot be maintained any longer. Since AWI has a strong interest in the continuation of the station it shall be replaced by an AWI automatic weather station during ANT LAND 2020/21.

FIDEMEKO2

PI: Angelika Humbert (AWI)

With repeated pRES measurements we are able to estimate the firn densification rate in the second and third densification state. This will serve as dataset for validation of the newly developed firm densification model solidFIDEMEKO. Kohnen is chosen as a location of cold firn with low accumulation rates.

1.5 Scientific flight campaigns POLAR 5

RIISERBATHY

PI: Graeme Eagles (AWI)

A full understanding of the glaciogenic processes within the East Antarctic Ice Sheet requires a sound knowledge of its exposed ice shelves and their underlying bathymetry. Basal melt rates of ice shelves have been shown to depend on the existing bathymetry due to its control on water circulation and mixing within the water cavity. Enhanced basal melt rates can destabilize the ice sheet and thus contribute to an overall loss of ice mass. Unfortunately, mass balance estimations models of ice sheets are still limited by sparse bathymetric information or inappropriate bathymetric assumptions beneath these ice shelves. To address the lack of bathymetry information beneath the floating ice shelves of Dronning Maud Land, airborne gravity data are used to model the underlying bathymetry. Gravity data directly resemble the mass distribution of the bedrock, overlying sediments, water and floating ice shelves and therefore

enable the modelling process. Within this project state-of the-art geophysical data - including gravity, magnetic and ice thickness radar data - will be acquired. The radar data determine the ice thickness and the position of the grounding line, while the magnetic data provide additional information of regional geological variations and the tectonic history.
Flight line spacing will vary from 5 km to 10 km mainly over the region of the Riiser-Larsen ice shelf and additionally over parts of the Ekström ice shelf to complement geophysical data acquired during the campaign in 2015/2016.

CAPS

PI: Horst Bornemann (AWI)

Censoring Animal Populations from Space (CAPS) focuses on the development of a cost-effective, remote sensing-based method for monitoring animal populations from space. As a bipolar initiative CAPS initially resumes the Antarctic Pack Ice Seals (APIS) Project of the former Group of Specialists on Seals (GSS) within the Scientific Committee on Antarctic Research (SCAR). APIS (1996 - 2001) aimed for a comprehensive circum-Antarctic investigation of the Antarctic pack ice seal stocks (crabeater, leopard, Weddell, and Ross seals), and considered in reconciliation with the Commission on the Conservation of Antarctic Marine Living Resources (CCAMLR) also investigations in feeding and distribution ecology. Under the working title APIS II, the Expert Group on Birds and Marine Mammals (EG-BAMM) within SCAR's Standing Scientific Group Life Science (SSG LS) seeks to resume the former seal survey in 2020. APIS II is part of CAPS and hence an integrated part of the Southern Ocean Observing Systems (SOOS), which in turn is an international initiative of the Scientific Committee on Oceanic Research (SCOR). APIS I integrated census from aircrafts, helicopters und ships over several years, APIS II, however, will be performed solely through analyses of satellite taken by WorldView-Satellites in one season. In doing so, APIS II it will reveal for the first-time trends in the status and stocks relative to APIS I. The interpretation of satellite images requires a preparatory ground truthing, in order to reconcile image data taken by aircrafts and satellites on spatially and temporally synchronous tracks. This reconciliation allows determining the detection probability for seals, and validating algorithms for automated image analysis Illustrative pictures/graphs are possible, but not required at the time of proposal submission and evaluation.

MEP

PI: Osama Mustafa (Think Jena, Germany)

Emperor penguins (Aptenodytes forsteri) are a characteristic species of the Antarctic. They live in one of the most extreme habitats on earth and have adapted their breeding cycle to the actually to the hostile conditions of the polar night. Their breeding area is the sea ice, usually near the cliffs of the ice shelf. The beginning of the breeding season in the southern winter is temperatures, strong storms, darkness and a lack of food and liquid water. The end of the breeding season is again limited by the break-up of the sea ice. In the course of climate change, considerable changes to the Southern Ocean ecosystem are to be expected. For the emperor penguins, the the changing occurrence of sea ice is particularly relevant. Within the framework of the Mapping Emperor Penguins at the Southern and Eastern Weddell Sea' project, aerial surveys of the emperor penguin colonies of the Southern and Eastern Weddell Sea are being carried out. The aim is to determine the size of the populations there. These data will be used to detect population changes and to investigate whether these changes to investigate whether these colonies are suitable for designation as a protected area.

1.7 Other scientific projects in Antarctica with AWI participation

Beyond-EPICA Oldest Ice

This year, a team of 12 people aiming to finalize camp installation, set-up and preparation of the drilling area, along with drilling of the pilot hole, reaming of the hole and installation of the casing. The complete drill system is planned to be installed and tested towards the end of the season. The temporary storage cave at Little Dome C Camp is also planned to be completed during this field season. (https://www.beyondepica.eu/en/about/field-diary/field-campaign-202122/)

2. LOGISTICAL OPERATIONS

2.1 Flight operations

Logistical operations are once more influenced by the COVID-19 pandemic, which further compels us to take special precautions to prevent the introduction of the virus to the continent. As a precautions measure, AWI decided not to use shared inbound flights of the Dronning Maud Land Air Network (DROMLAN) and chartered aircraft to fly from Cape Town to Antarctica. All participants have to undergo a 14-day quarantine in Cape Town and three negative PCR tests before they are allowed to fly to NEUMAYER STATION III and strictly following the COMNAP COVID-19 Outbreak Prevention & Management Guidelines for the 2021/22 Antarctic season. Additionally, the DROMLAN put a Sanitary Protocol for using the airlink between Cape Town and Novo Runway in place and all participating nations agreed on it.
In total, AWI is using three dedicated intercontinental flights between Cape Town and Wolfs Fang to deploy in total 67 participants into NEUMAYER STATION III and KOHNEN STATION. The first flight is planned for the beginning of November 2021. For participants leaving NEUMAYER STATION III, we will use DROMLAN as well, with the last summer personnel leaving NEUMAYER STATION III end of February 2022. All personnel will be transported via airlink.

2.2 Ship calls

The main cargo of the station will be transported to/from NEUMAYER STATION III by MV MALIK ARCTICA. The first ship call at ATKA BAY is planned for the end of December 2021. On this first call, the provisions for the next winter, general cargo for maintaining the station, scientific equipment, vehicles and fuel will be delivered. MV MALIK ARCTICA will then divert to other offloading sites of charter partners and will then come back for discharging. The operations with MV MALIK ARCTICA will be finished by January 2022.
RV POLARSTERN will call at Atka Bay on the PS129 cruise.

3. NATIONAL AND INTERNATIONAL VISITS

No visits are planned in season 2021/22.

4. PARTICIPANTS

Name	First Name	Project
Asseng	Jölund	Geophysical observatory
Baden	Markus	Wintering 2021
Bähler	Stefanie	Technical inspection
Behrens	Melanie	ISOAnt
Beyer	Mario	Technical team
Birk	Tobias	Pistenbully maintenance
Böddeker	Karsten	Wintering 2022
Bosiger	Yoland	Media
Buchta	Eric	DML_GIA
Bunchek	Jess	Wintering 2021
Dinter	Tilman	IT
Dornhöfer	Timo	Wintering 2021
Doron	Tanguy	Wintering 2021
Drews	Reinhard	ReMeltRadar
Eagles	Graeme	Aircraft campaigns
Eigendorf	Thomas	DNV-GL
Eisen	Olaf	MIMO-EIS
Eisermann	Hannes	Aircraft campaigns
Ershadi	Reza	ReMeltRadar
Fromm	Tanja	Grouze
Gebhard	Eduard	Aircraft campaigns
Graeser	Jürgen	Meteorological observatory
Grasse	Torsten	CTBTO
Guba	Klaus	Doctor Kohnen Station
Hagemeister	Wilhelm	IgH
Hawkins	Jonathan	ReMeltRadar
Heuck	Hinnerk	Technical team leader
Hoffmann	Mathias	CTBTO
Hofmann	Werner	Wintering 2022
Hölzer	Aurelia	Wintering 2022
Hornik	Jonas	Technical team
Houstin	Aymeric	MARE
Hüther	Matthias	Beyond EPICA Oldest Ice
Immoor	Sebastian	IT
Jonczyk	Peter	Wintering 2021
Keck	Hannes	Wintering 2022
Kinzel	Louisa	Geophysical observatory
Kipfstuhl	Sepp	SLIFT
Klawitter	Hendrik	Technical team Kohnen Station
Koch	Florian	Wintering 2021

Koch	Inka	ReMeltRadar
Köhler	Peter	Kottaspegel, AWS Kohnen, FIDEMEKO2
Köhler	Peter	Field Operations Manager (second half)
LeBohec	Celine	MARE
Lewis	Justin	Media
Marten	Lorenz	Wintering 2021
McKeever	Casper	Media
Mitteregger	Christian	Technical team Kohnen Station
Neuner	Benedikt	Technical team
Oblender	Andreas	Techniical team Kohnen Station
Ockenfuß	Paul	Wintering 2021
Ort	Linda	Wintering 2021
Peter	Dirk	Cook Kohnen Station
Petersen	Christoph	Aircraft campaign
Petri	Martin	IT
Preis	Loretta	Meteorological observatory
Reich	Stefan	Technical team Kohnen Station
Riess	Felix	IT inspection
Ritter	Oliver	MT_ANT3
Rohnacher	Alicia	Wintering 2022
Roth	Hans-Peter	Technical team
Schroeter	Benjamin	DML_GIA
Schubert	Holger	Technical team Kohnen Station
Schulze	Markus	Wintering 2022
Schütt	Philipp	Technical team
Steimke	Olaf	KSF
Steiner	Ladina	GNSS-RR
Thoma	Theresa	Wintering 2021
Trautmann	Michael	Wintering 2022
Vail	Alexander	Media
Wagner	Benita	Wintering 2022
Weckmann	Ute	MT_ANT3
Wesche	Christine	Field Operations Manager (first half)
Widdecke	Iris	Housekeeping
Wiggins	Katrin	Wintering 2022
Winterl	Alexander	SPOT/MARE
Zitterbart	Daniel	SPOT/MARE

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