FINNARP

Field Operations 2022–23

Content

Expedition members are walking roped up on a glacier towards Aboa. Photo: Priit Tisler/ FINNARP

Photo: Mika Kalakoski | FINNARP

Coverphoto: Expedition members hiking at the Basen nunatak. Photo: Jussi Heinonen/ FINNARP

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Editorial

Finland's Antarctic research activities are back in full swing after the COVID-19 pandemic. Scientists have been busy working at Finland's own research station Aboa and at the stations and research ships of Argentinian, Chilean, Italian-French, South African, and New Zealand's Antarctic programs. Only with international cooperation, scientific fieldwork in different parts of Antarctica is possible.

Due to the reshaping of the world, logistical arrangements to reach Aboa had to be reorganized. Close cooperation with our partners allowed to find new flight routes to Aboa both for the FINNARP personnel and freight. FINNARP 2022 expedition traveled to Antarctica with a flight organized by the Norwegian Polar Institute. The intra-Antarctic flights and the expedition's return flight were arranged by the White Desert company. Sea freight from Finland was shipped to the German Neumayer III station and from there by aircraft to Aboa with the assistance of the German Alfred Wegener Institute. Close cooperation was also carried out at the Nordenskiöld Base Camp with the Swedish Polar Secretariat.

Cooperation and trust are prerequisites for successful Antarctic research. FINNARP Operations and scientists thank their partners and the Antarctic community for a successful field season.

Mika Kalakoski
Manager, FINNARP/ Finnish Meteorological Institute

The Finnish Antarctic research program FINNARP carried out FINNARP 2022 research expedition to the Finnish Antarctic Station Aboa between November 2022 and February 2023. Five FINNARP employees, two researchers from the Finnish Meteorological Institute (FMI), two researchers from the University of Helsinki (HU), and one researcher from the National Land Survey of Finland (NLS) participated in the expedition.

The FINNARP 2022 expedition set off to the research station Aboa on November 8, 2022. The expedition team traveled first from Helsinki to Oslo, from where they flew with a flight organized by the Norwegian Polar Secretariat via Cape Town, South Africa, to Norway's Troll Station. From there, the expedition traveled by ski-equipped aircraft, operated by White Desert company, to Aboa. The FINNARP technicians with their cargo arrived at Aboa on Friday evening, 11 November 2022. The researchers arrived two days later. The expedition team consisted of the expedition leader, senior specialist, cook, mechanic, doctor, and as well three snow and ice researchers from the Finnish Meteorological Institute (FMI) and the National Land Surveying Institute (NLS), and two geologists from the Finnish Museum of Natural History, Helsinki University (HU).

Aboa had wintered well despite the severe Antarctic winter storms. The damage to the station's structures and technology was minor, although a lot of snow had accumulated in the vicinity of the station during the winter. The station start-up went without any major difficulties and the generators were turned on immediately after the first team had arrived at Aboa.

The weather during the expedition was variable. Aboa was battered by several Antarctic summer storms with winds reaching hurricane readings. Wind gusts of more than 40 m/s were measured, and all scientific and maintenance work was done indoors. Despite the unstable weather, all planned works were completed in time and scientific goals were met.

FINNARP 2022 Expedition during Christmas time at Aboa. Photo: Aleksi Rimali/ FINNARP

Research station Aboa. Photo: Pasi Ylirisku|FINNARP

The FMI and NLS scientists measured the physical properties of snow, the surface roughness of snow and ice, and the reflectivity, or albedo, around the Aboa station. Among other things, drones were used in the measurements and snow pit measurements were made. Also, the three scientists measured the surface roughness of the sea ice during the four-day field trip in the Rampen area, located 150 km to the coast. The HU geologists studied the volcanic bedrock of Vestfjella near Aboa station. During the expedition, geologists took notes on the extent, thickness, and internal structures of the lava layers and collected samples from the lava layers.

The expedition's technical personnel were responsible for the operation of the station and its equipment. The station's permanent measuring equipment was serviced, and the data was collected for scientific analysis. The station's automatic weather station was thoroughly serviced and new sensors and a recording system were installed. At the same time, a new satellite system was installed, which allows Aboa's weather observations to be transmitted daily to the international network. In addition, the station was subject to routine maintenance and repairments. Station vehicles, such as snowmobiles, tracked transport vehicles, SUVs, and a tractor were serviced and repaired.

FINNARP 2022 Expedition

Mika Kalakoski | expedition leader
Priit Tisler | senior specialist
Jukka Huumonen | medical doctor
Tapio Hyppänen | mechanical engineer
Sanna Häkkänen | chef
Leena Leppänen | scientist
Aleksi Rimali | scientist
Antero Kukko | scientist
Arto Luttinen | scientist
Jussi Heinonen |scientist

Expedition members descending a steep snow slope.
Photo: Aleksi Rimali/ FINNARP

Measuring devices and campaigns at Aboa during the austral summer 2022/23

Measuring campaigns:

- Snow and ice surveys by the Finnish Meteorological Institute (FMI) and the National Land Survey of Finland (NLS) in the vicinity of Aboa and during a 4-day field trip to the Rampen area, about 150 km to the coast.
- Geological studies of the University of Helsinki (HU) in the vicinity of Aboa.

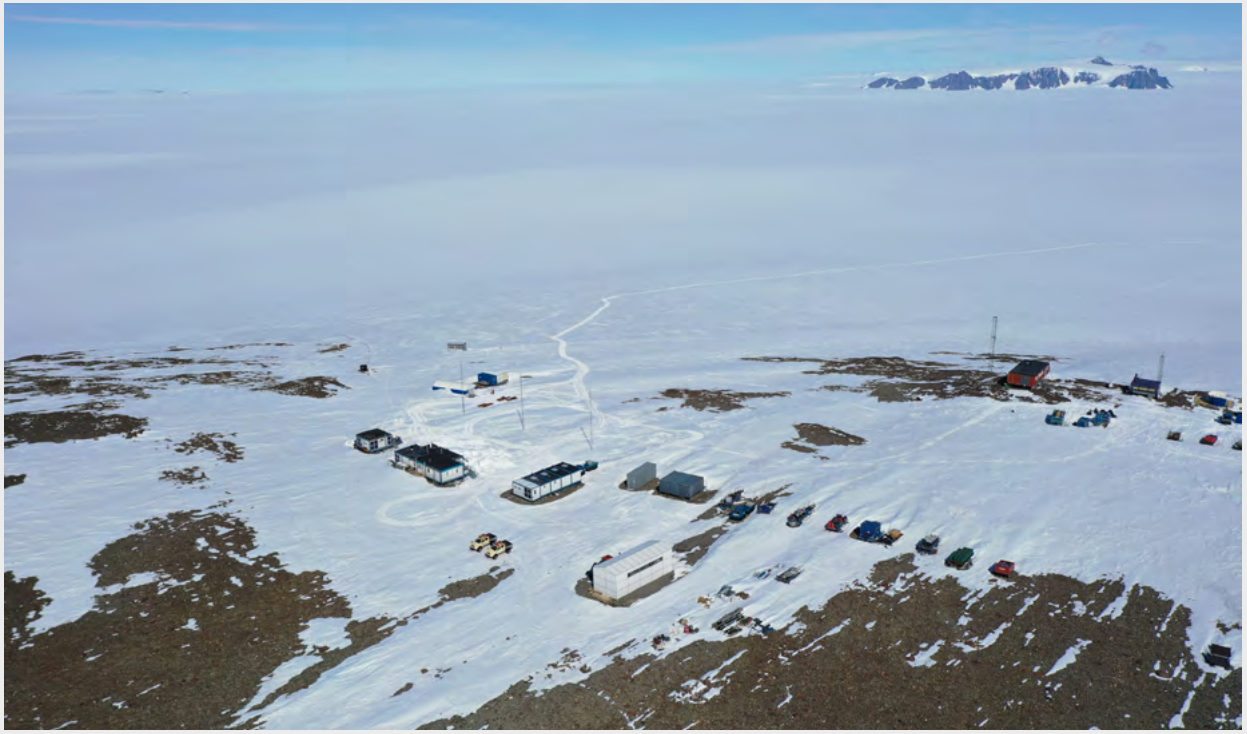
Automated year-round measuring devices:

- Automatic weather station (FMI) at Aboa was maintained. Ceilometer was in use during the expedition to determine the height of a cloud base.
- Automatic weather station (FMI), 10 km from Aboa, was maintained.
- Seismometer (HU) to measure earth movements at Aboa was maintained. Portable seismometers (HU) were installed at Fossilryggen and Plogen nunataks for the season.
- GPS equipment (NLS) to support geodetic studies was maintained.

The expedition team closed the research station on January 31, 2023. From Aboa, the team traveled by ski-equipped aircraft, operated by White Desert company, to Wolf's Fang Runway. From there the team continued their journey to Cape Town with a White Desert cargo aircraft. The expedition team returned to Finland by February 3, 2023. Research station Aboa was occupied for 82 days.

Finland's Antarctic research station Aboa

- Finland's Antarctic research station Aboa is located on Queen Maud's land about 130 kilometers from the coast and about 5,000 kilometers from Cape Town, South Africa. The research station was built in Antarctica during the summer of 1988–1989. After the construction of its research station, regular research trips to Antarctica have been made from Finland.
- Research trips are usually made between November and February when it is summer in Antarctica and the temperature stays between 0 and 20 degrees below zero. Antarctic summer is characterized by constant light and strong solar radiation, as well as strong snowstorms.
- Finland's Antarctic operations FINNARP, operating at the Finnish Meteorological Institute, organizes annual research expeditions to Aboa and supports the fieldwork of projects funded by the Academy of Finland in different parts of Antarctica. The research work of the FINNARP expeditions is mainly focused on Queen Maud's land and the research station in the vicinity of Aboa.
- Finland is a member of the Antarctic Treaty. A prerequisite for this is the implementation of significant research activities in the region. The Academy of Finland's new four-year funding period for Antarctic research began last year.



Aerial photo of Aboa station. Photo: Aleksi Rimali/ FINNARP

Maintenance of antenna mast near the Aboa station. Photo: Priit Tisler/ FINNARP

Aboa's all-terrain transport vehicles are parked in front of the station. Photo: Priit Tisler/ FINNARP

Expedition leader Mika Kalakoski at the top of Basen. Photo: Priit Tisler/ FINNARP

Snow research around Aboa station

The aim of the field campaign was to collect observational data of snow surface roughness, reflectivity, and physical properties in the vicinity of Aboa station. Research work, during the FINNARP 2022 expedition, was carried out by Leena Leppänen and Aleksi Rimali from the Finnish Meteorological Institute and Antero Kukko from the National Land Survey of Finland.

Measurements were made regularly close to the AWS5 weather station and at overpass locations of IceSAT and Cryosat satellites. Mainly, measurements were made approximately 5–40 km from the station. In addition, a four-night Rampen route field trip was made, along with measurements over self-ice and sea ice. Total of 24 measurement sessions were undertaken during the season.

Surface roughness of the snow and sea ice was measured with a gas-powered drone carrying a laser scanner. In addition, laser scanning was made with a portable backpack system when the drone was not in operation.

Drone-based hyperspectral camera and broadband radiation sensor were used for observations of solar radiation. Moreover, incoming and outgoing broadband radiation was measured with a ground-based sensor. Spectral reflectance of radiation with different wavelengths was measured with a spectrometer.

Several snowpit measurements were carried out in order to study physical properties of the snow, consisting of measurements of snow density, temperature, liquid water content, specific surface area, stratigraphy with layer hardness, wetness, grain size, and grain type. In addition, spatial variability of snow surface properties were observed at five points inside the drone measurement area, similarly to snowpit measurements.

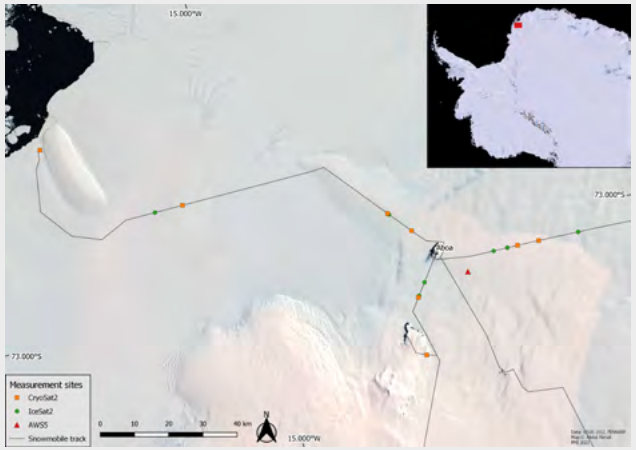
This research is part of the "Low orbit altimetry, Albedo, and Antarctic Snow and Sea-ice Surface Roughness (LAS3R)" project funded by the Academy of Finland. Major aim of the project is to study the effect of snow surface roughness on satellite altimeter observations and optical measurements.

Radiation station was installed close to the AWS5 weather station ~10 km away from Aboa to measure over the season. Plogen nunatak behind. Photo: Aleksi Rimali/ FINNARP

Leena is measuring physical snow properties at snow pit. Photo: Antero Kukko/ FINNARP

Aleksi is preparing radiation drone for the measurements. Payload of the drone is a hyperspectral camera and a broadband radiation sensor. Photo: Leppänen/ FINNARP

Measurement locations around Aboa station. Photo: Leppänen/ FINNARP



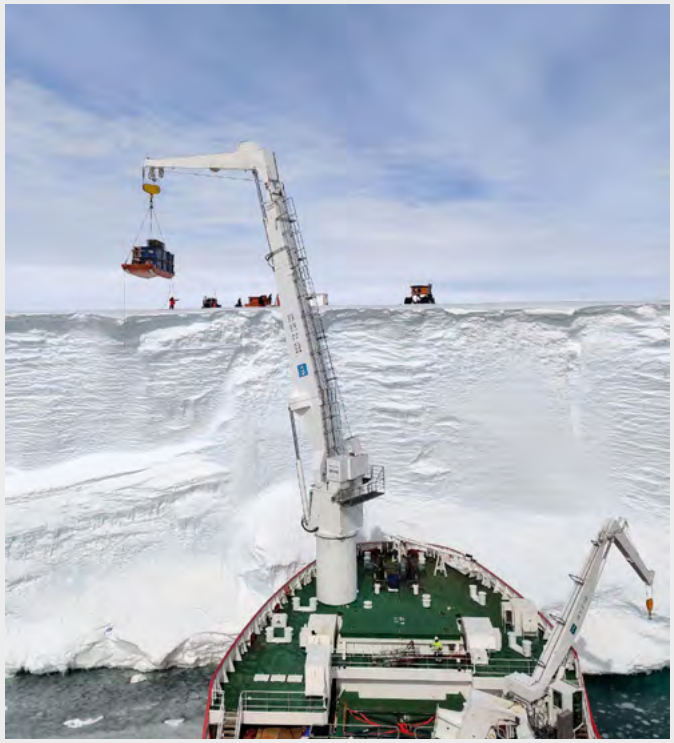
Ice load measurements onboard S.A. Agulhas II

Scientists from Aalto University and the Finnish Meteorological Institute (FMI) participated in two cruises on board the South African research vessel S.A. Agulhas II during the 2022/2023 season. Marek Muchow (Aalto) and Jan-Viktor Björkqvist (FMI) were part of the Southern Ocean Seasonal Experiment (SCALE) Winter Cruise of 2022 (SCALEWIN22) from 11th to 31st July 2022; and Andrei Sandru (Aalto), Yaxuan Zhu (Aalto) and Jaakko Seppänen (FMI) were part of 2022/2023 SANAE Antarctica annual relief voyage (SANAE 22/23) from 16th December 2022 to 13th February 2023.

SCALEWIN22 is an interdisciplinary project to fill the gap in sea-ice knowledge during the Austral winter and was joined by around 75 scientists from 20 different institutions. During this cruise, a collaborative team consisting of scientists from Stellenbosch University (South Africa) and RTWH Aachen (Germany) supported each other. SANAE 22/23 was the annual relief voyage to the South African Antarctic Base, SANAE IV, and also to the summer base. The voyage was during the Austral summer. Together with the overwintering crew, there were also around 45 scientists studying Antarctica from different perspectives. Research on Antarctic sea ice, oceanography, and animals was actively carried out.

Aalto Team assisting the maintenance of the SA Summer Base. Photo: Jaakko Seppänen

Aalto/FMI team during 2022 summer relief voyage, with a Finnish flag. Photo: Eric Buchta



Cargo offloading from the ship to the ice shelf, which is around 30 metres above water. Photo: Andrei Sandru

Antarctic shelf next at Penguin bukta. Photo: Andrei Sandru

Electromagnetic sounder inside the kayak measuring sea ice thickness. Photo: Jaakko Seppänen

During both cruises, Aalto University measured the ice loads on the hull of S.A. Agulhas II while being in the marginal ice zone and near the Antarctic ice shelf. Parallel observations about ice conditions including sea ice concentration, thickness, and floe size were conducted. The ice conditions were monitored through visual observations but also by using cameras and an electromagnetic (EM) device provided by FMI. The aim of the research is to study the behavior of sea ice in the marginal ice zone and the effects of the ice on the ship.

Aerosol measurement in Antarctica

Atmospheric aerosol particles have various impacts on climate: they scatter radiation, form clouds, and modify the reflectance of snow- and ice surfaces. During the summer season 2022 – 2023 at Marambio station, an intensive atmospheric measurement campaign was carried out to investigate sources and climate-forcing properties of atmospheric aerosols. The instrumentation deployed during the campaign was complementary to the existing measurement infrastructure that is operated at Marambio as a collaboration between the Finnish Meteorological Institute, the Institute for Atmospheric and Earth System Research (INAR), and the Argentinian weather service (SMN, Servicio Meteorológico Nacional Argentina).

The comprehensive suite of instrumentation included online and offline techniques to measure atmospheric vapors (including e.g. ammonia and sulfuric acid), and to detect and count atmospheric aerosols as well as measure their chemical compositions, physical properties, and cloud formation potential. In addition, microbiological samples were collected to assess the role of microorganisms, such as bacteria, fungal spores, algae, and viruses, in the overall aerosol population and atmospheric processes at Marambio.

The scientific instruments were installed in a measurement container located 500 m away from the main station. The daily routine at the container consisted of analyzing samples as well as checking, maintaining, and calibrating the instruments.

Simultaneously with the Marambio campaign, comparison measurements we carried out on board RV Hesperides between February – March 2023. Measurements were conducted in the vicinity of the Antarctic peninsula to get insight into the geographical extent of processes investigated in detail at Marambio.

This fieldwork was part of the Antarctic Climate Forcing Aerosol (ACFA) project funded by the Academy of Finland and was conducted under a consortium set up between the Institute for Atmospheric and Earth System Research (INAR) of the University of Helsinki, the Finnish Meteorological Institute (FMI), and the Molecular and Integrative Biosciences Research Programme (MIBS) of the University of Helsinki.

Fieldwork at Marambio was carried out by Matt Boyer (INAR), Zoé Brasseur (INAR), and Svetlana Sofieva (FMI), with the participation of Giselle Marincovich (SMN) and Ann-Kathrin Goßmann (Palas ®). Measurements on board RV Hesperides were conducted by Lauriane Quelever (INAR)

In addition to the research conducted at Marambio and its surroundings cooperation within the ACFA project was active with Italian and American scientists. In December 2022 Italian scientists from the CNR-ISAC research institute installed two aerosol instruments at the French-Italian Concordia station on the East Antarctic high plateau, about 3200 m above sea level and 1100 km from the coast. In January 2023 a scientist from the American NOAA research organization installed an aerosol instrument built at the University of Helsinki to the South Pole Observatory at the American Amundsen-Scott research station. Both measurements are part of an ACFA work package investigating the long-range transport of aerosols.

Measurement instrumentation is located in the southern part of the island in a separate sea container. Photo: Matt Boyer

Matt Boyer installing a sampler. Photo: Matt Boyer

Argentinian Marambio station is located on the tip of the Antarctic peninsula on an island. In summer the station is surrounded by the open sea. Photo: Matt Boyer

Iron limitation on primary productivity in the Marginal Ice Zone of the Southern Ocean – unraveling the role of bacteria as mediators in the iron cycle (IMICROBE)

Trace metal iron limits phytoplankton primary productivity in large parts of the Southern Ocean. Processes in phytoplankton iron acquisition are complex and not well known. The objectives of the IMICROBE project were to study the role of bacteria in phytoplankton iron supply in the Southern Ocean through field and experimental work, as well as understand large-scale consequences of bacterial iron acquisition and transfer with biogeochemical modeling.

Southern Ocean research cruise organization was rather challenging during the global pandemic and planned cruises were moved or canceled altogether. IMICROBE researchers Letizia Tedesco and Lumi Haraguchi from the Finnish Environment Institute took part in the South African research cruise SCALES-WIN22 from Cape Town to marginal ice zone onboard r/v Agulhas from July 11th to 30th 2022. On the cruise, they collected samples from bacterial and plankton communities as well as nucleic acids from different water layers and sea ice. Samples were collected from zones differing by their inherent iron availability. In addition, experimental work on iron additions to phytoplankton and bacterial communities was carried out. IMICROBE researchers also conducted measurements on under-ice irradiance and water column characteristics in the marginal ice zone.

Work onboard included field measurements and sampling from water and sea ice, experimental work and significant laboratory work e.g. sample preparation for metagenomic analyses, flow cytometry, and protist-bacteria grazing experiments. IMICROBE team conducted close collaboration with other research groups onboard and also presented a seminar on 28.7. on the sea ice ecosystem and the project itself.

The Finnish delegation (from left to right: Jan-Victor Björkvist (FMI), Marek Muchow (Aalto University), Lumi Haraguchi (Syke) and Letizia Tedesco (Syke)) with FINNARP gear, in the marginal ice zone. Photo: Kurt Martin (@kurt_artin)

Lumi Haraguchi presents CytoSense flow cytometer to colleagues. Photo: Sizwekazi Yapi

Letizia Tedesco sampling ice from a floe lifted onboard. Photo: Letizia Tedesco

Working on ice from the crane basket. Photo: Letizia Tedesco

Geological studies of Vestfjalla bedrock

Geologists from the Finnish Museum of Natural History (LUOMUS), University of Helsinki, took part in the FINNARP 2022 expedition to the research station Aboa. Dr. Arto Luttinen and Dr. Jussi Heinonen carried out a detailed mapping of the volcanic succession that constitutes the exposed bedrock of Vestfjella. The outcrops represent remnants of a very large volcanic system that had a global impact on the Jurassic world.

The mapping included flow-by-flow volcanological observations and sampling of the Basen and Plogen nunataks that record up to 800 m thick lava pile. The team also carried out over 1000 on-site chemical analyses of lava samples using a portable X-ray fluorescence spectrometer.

Jussi Heinonen examines lava layers at Basen. The upper part of the photo shows a layer of grey sandstone. Photo: Arto Luttinen

Analyzing samples in the research container using X-ray fluorescence spectrometer (XRF) Photo: Jussi Heinonen

The lava formation is well-exposed in the northwestern cliff of Basen. Note human on the glacier. Photo: Jussi Heinonen

Fossil pipe vesicles (bottom left) and ropy structures (center) reveal the directions of lava flows. Photo: Arto Luttinen

The lava morphology and dimensions, the amount and distribution of fossil degassing bubbles, and the chemical compositions indicate that 1) the lava layers flowed from three different volcanoes, 2) the eruption and flow rates were relatively low, and 3) the formation of lava flow fields was episodic, with clastic interbeds demonstrating major pauses between the eruptive episodes.

These findings provide critical constraints on the environmental impact of the atmospheric release of volcanic gases. Overall, the results are compatible with a correlation of eruptive activity with minor to moderate global biosphere crises. The geological fieldwork was related to VALVE project (Volatiles and Large Volcanic Eruptions) funded by the Academy of Finland.

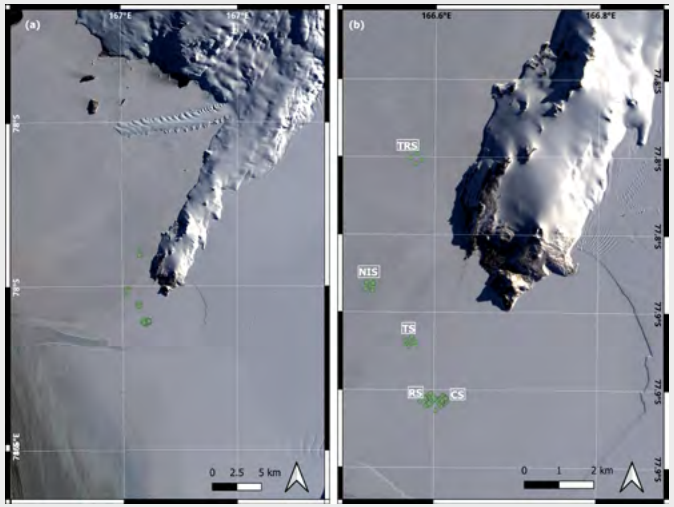
The physics of snow on sea-ice: Finnish Meteorological Institute's (FMI) contribution to the Marsden field campaign at McMurdo Sound

In November 2022 FMI scientist Roberta Pirazzini participated in a New Zealand field campaign in the land-fast ice of McMurdo Sound to assess the spatial variability of snow mass and its optical and thermal properties in the spatial scales of model grid cells (Fig 1). The campaign was organized in the framework of the New Zealand Antarctic project "Can Snow Change the Fate of Antarctic Sea Ice?" funded by the Marsden Fund.

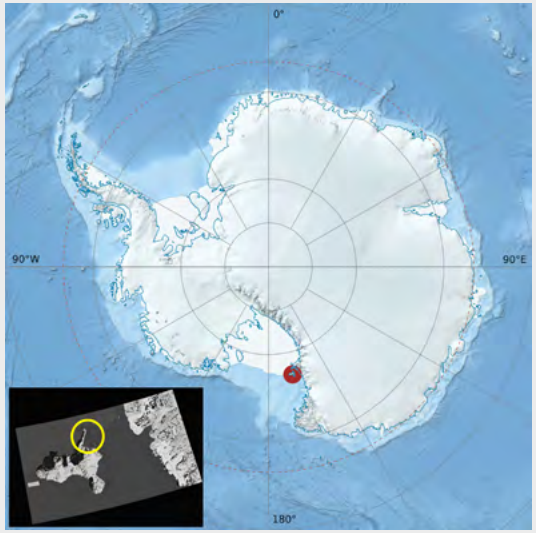
The field camp was established over 2.4 thick land-fast sea ice (Fig 2), about 5 km from the Scott Base station (NZ) and 4 km from McMurdo station (US). FMI contributed to the campaign with drone-based surface albedo measurements (Fig 3a) as well as optical and thermal surface mapping, and with surface-based broadband and spectral radiation measurements (Fig 3b) and snow and mass balance (SIMBA) buoy measurements.

In addition, an automated weather station provided basic meteorological data, and detailed snow physical properties (temperature, salinity, density, specific surface area, snow water equivalent) were measured almost daily on snow pits and along transects. Spatial variability of snow and ice thickness were measured, respectively, with a magnetostrictive device (MagnaProbe) carried around by feet and with an electromagnetic induction device (EM-31) carried on a sled.

Snow thickness was generally very variable, ranging from 0 to 40 cm, with the largest snow accumulation occurring over the roughest ice. The surface albedo reflected this snow variability, being largest where snow depth exceeded the optical thickness of 20-30 cm sufficient to screen out the underlying ice. Moreover, dust from nearby mountains accumulated on the downwind side of surface rough features, contributing to locally lower albedo, increase temperature, and enhance the spatial heterogeneity of the surface energy budget.



Location of the Marsden field campaign in McMurdo Sound, Antarctica. The logistic was supported by the New Zealand Scott Base located in Ross Island (in (a), the zoomed area in the lower left corner, at the center of the yellow circle). The measurements were carried out on the land-fast sea ice over four selected areas marked in green in (b) and (c) to capture the spatial variability of the surface properties.



Ice camp of the NZ Marsden campaign on McMurdo Sound. Photo R. Pirazzini

Drone Spectra equipped with upward and downward-looking Kipp and Zonen CM4 pyranometers and Ocean Optics STS VIS and NIR spectro-radiometers for broadband and spectral albedo measurements. Photo: J. Martin

Broadband radiation station powered with solar panels. Photo: J. Martin

Microbe and plant research in King George Island

Scientists Marjo Helander and Kari Saikkonen, University of Turku, participated in the Chilean Antarctic Institute (INACH) scientific Antarctic expedition 59 (ECA59) to the Professor Julio Escudero Base in King George Island (62º12'57"S, 58º57'35"W), Antarctica in 2023. During the three weeks visit they collected microbiome samples and Deschampsia antarctica plants from several sites in Fildes Peninsula for the Academy of Finland-funded MICROBIPOLAR -project (Climate Change Driven Microbiomes and Adaptive Radiation of Plants in the Polar Regions).

Deschampsia antarctica is one of the two native vascular plant species in Antarctica. MICROBIPOLAR-project focuses on how plant-associated microbes facilitate plant adaptations to polar regions where months of continuous light are followed by months of darkness. Unlike temperature, the latitudinal gradient of seasonal changes in day length is a stable, environmental factor that does not change with local or global climate. Thus, predicting range expansions across latitudes and consequences for native communities requires an understanding of how species use day length to coordinate their seasonal growth and reproduction.

In a series of field samplings and transplantation experiments, they will examine microbiomes in the Arctic and Antarctica, and plants ability to expand their ranges polewards in warming climate. Description of microbiomes and their genetic adaptability allows them to estimate global dispersion and diversification of cold-adapted microbes. Field experiments aid them to understand how microbes and key gene functions jointly affect adaptive evolution of plants in the Polar Regions.

The invaluable contribution from Marcelo Gonzalez-Aravena, César Cárdenas, Ignacio Reyes, and all the logistic, field, and laboratory staff is acknowledged. With their help, Helander and Saikkonen were successfully able to collect samples from six grass populations and process the genome and microbiome samples in the well-equipped Escudero Base laboratory.

Leaving for a sampling trip from Escudaro Base.
Photos: Kari Saikkonen

Kari Saikkonen collecting Deschampsia antarctica grasses at Bahia Collins.

Returning from Bahia Collins with samples.

Preparing microbiota samples in Escudero Base laboratory.

Behavioral Team Dynamics Research at Aboa during the FINNARP 2022 expedition

During the Antarctic season 2022/23, Andres Käosaar (University of Central Florida, US) continued data gathering for the research project "Team resilience and teamwork in isolated, confined, and extreme environments". This was the second part of the study for which teams operating at the Aboa station filled in weekly surveys about their teamwork experiences during the field season. The first part of the study was completed during the FINNARP 2021 expedition.

The purpose of this research is to study the challenges teams in Isolated, Confined, and Extreme (ICE) environments face and how the individuals nested in teams perceive and react to those challenges. This year, an added emphasis on understanding the dynamics of the different teams part of the FINNARP 2022 expedition was included. More specifically, apart from general dynamics and challenges a team goes through in their work, in a multiteam system (i.e., several subteams working as part of a bigger team), additional dynamics and challenges related to communication and coordination between the different teams are often present. Thus, additional questions related to the dynamics of the Aboa multiteam systems were focused on.

Six FINNARP 2022 expedition members filled in a pre-expedition survey, a weekly survey, and a post-expedition survey, and participated in a post-expedition interview.

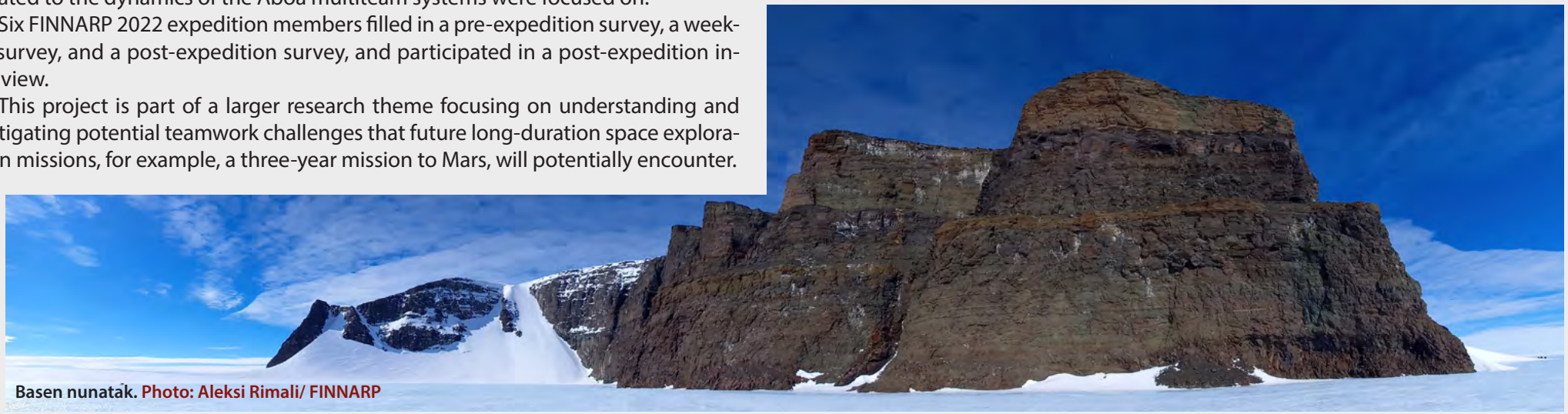
This project is part of a larger research theme focusing on understanding and mitigating potential teamwork challenges that future long-duration space exploration missions, for example, a three-year mission to Mars, will potentially encounter.

Master's Thesis "Air traffic change in Finland's Antarctic mission 2009–2020"

Ville Mertamo, a master's student from the South-Eastern Finland University of Applied Sciences, is currently working on a master's thesis with the topic "Changes in air traffic in Finland's Antarctic operation 2009–2020". The main idea of the thesis was agreed upon with the head of FINNARP operations, Mika Kalakoski, in the fall of 2020, and the actual work began in April 2022. Mertamo aims to finish the thesis in the early fall of 2023.

The main research questions are: What are the most important factors in the cargo and passenger transport of Finnish Antarctic air logistics? The topic is approached from the following perspectives:

- Sustainable logistics (e.g., packaging materials, optimization of air cargo)
- Managing the risk of logistical plans
- The impact of cooperation
- Adequacy of project resources (budget) in terms of the expedition logistics



Basen nunatak. Photo: Aleksi Rimali/ FINNARP