



FRENCH POLAR
inSTITUTE
PAUL-ÉMILE VICTOR



Annual report
summer CAMPAIGN

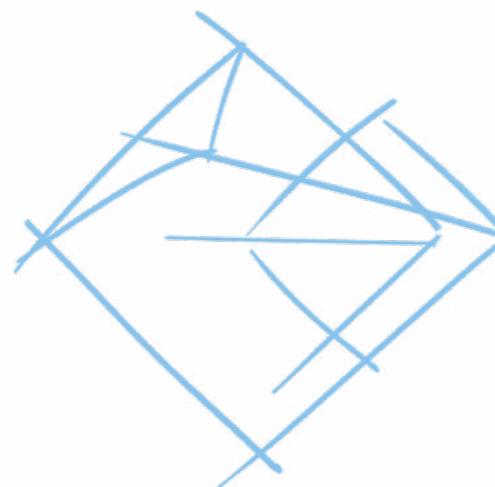
2019
2020



Annual report 2019-2020



FRENCH
POLAR
inSTITUTE
PAUL-ÉMILE VICTOR



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Gaëlle Sellin : p. 13
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Charline Giguet : p. 24
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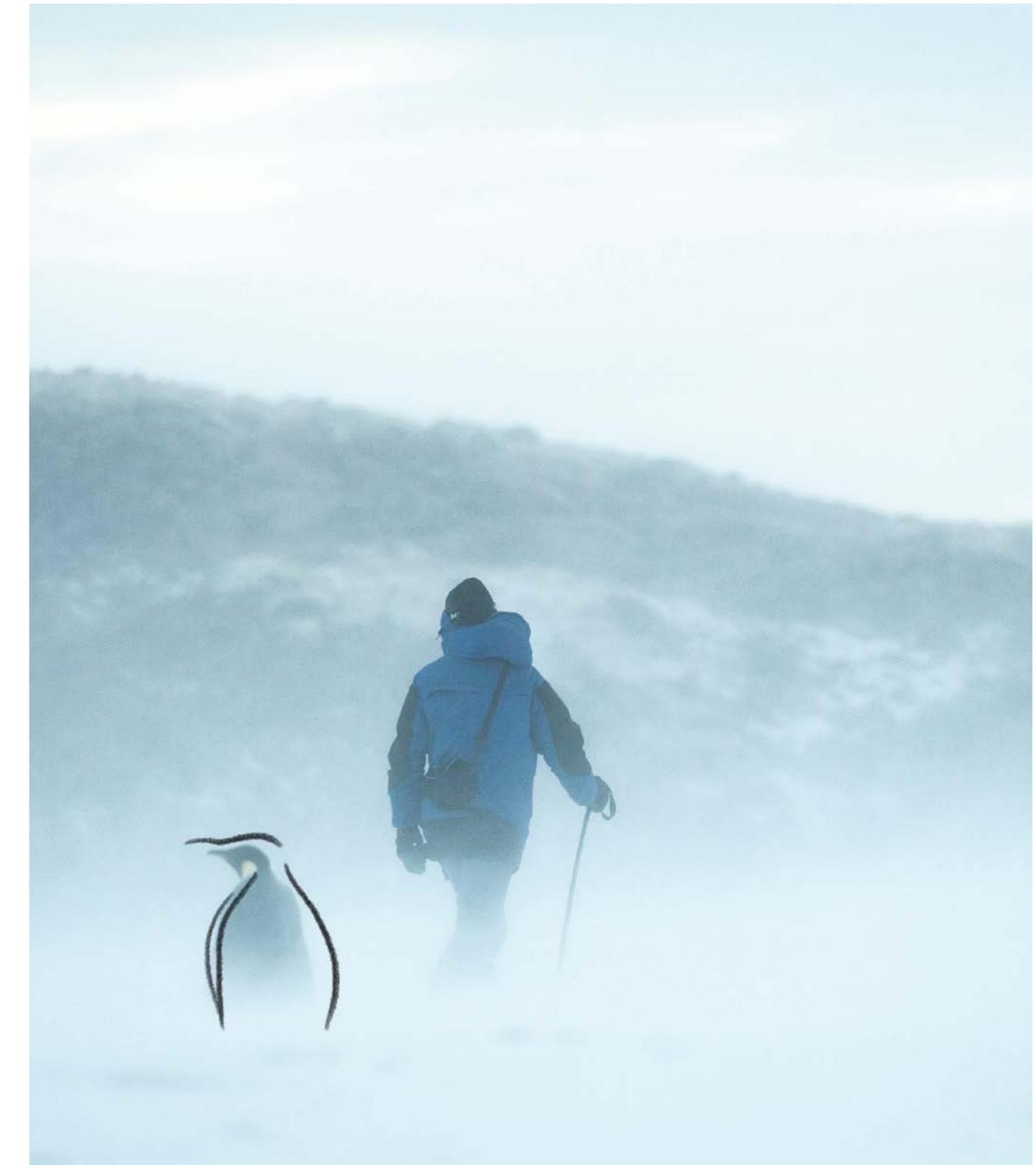


INFORMATION:
This English version
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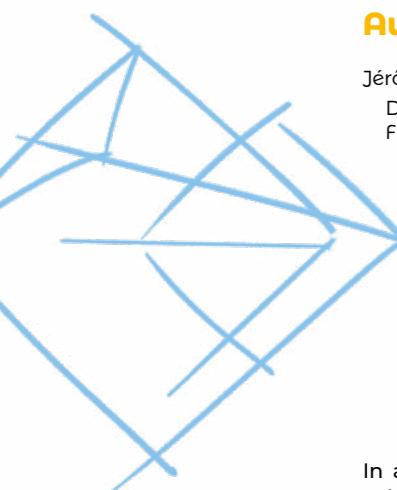


A mixed year of joys and hardships

EDITORIAL

Author

Jérôme CHAPPELLAZ
Director of the French Polar Institute



In all three cases, the missions were a complete success. The PALAS 2 team managed to extract a total of 127 m of lake cores, obtained from 6 different lakes and 14 coring sites. Their analyses will provide an exceptional look at the climatic and environmental evolution of this poorly documented sector of the planet. For the Beyond EPICA project, it was possible to install the main elements of the camp. This is an immense logistical challenge because it must be possible for a team of approximately fifteen people to live there and to be completely self-sufficient during close to 60 consecutive days each season and for 5 consecutive summer campaigns, one after the other. Last, the EAIST scientific traverse continued to help revive the great scientific exploration expeditions in the best way possible; the Polar Institute had received equipment for this in the early 2010s. This was the fourth expedition of its kind for the Institute, and it was possible to travel more than 1300 km into unknown territories, to the centre of the Antarctic plateau consisting primarily of megadunes and "glazed" surfaces. Through the numerous fieldwork projects, it was possible to collect close to 1000 m of accumulated snow and ice cores, which will enable researchers to better understand the origin of these unique structures on Earth as well as to quantify the contribution of this large Antarctic sector to global sea level changes. For both the PALAS 2 project and the EAIST project, the 2019-2020 activity report includes a detailed scientific focus, written by their scientific coordinators as soon as they got back from the field. I would like to thank them very much for this.

The time has come to present the new activity report for the French Polar Institute, which covers the 2019 calendar year as well as the 2019-2020 austral summer campaign. The results are mixed, with both highs and lows.

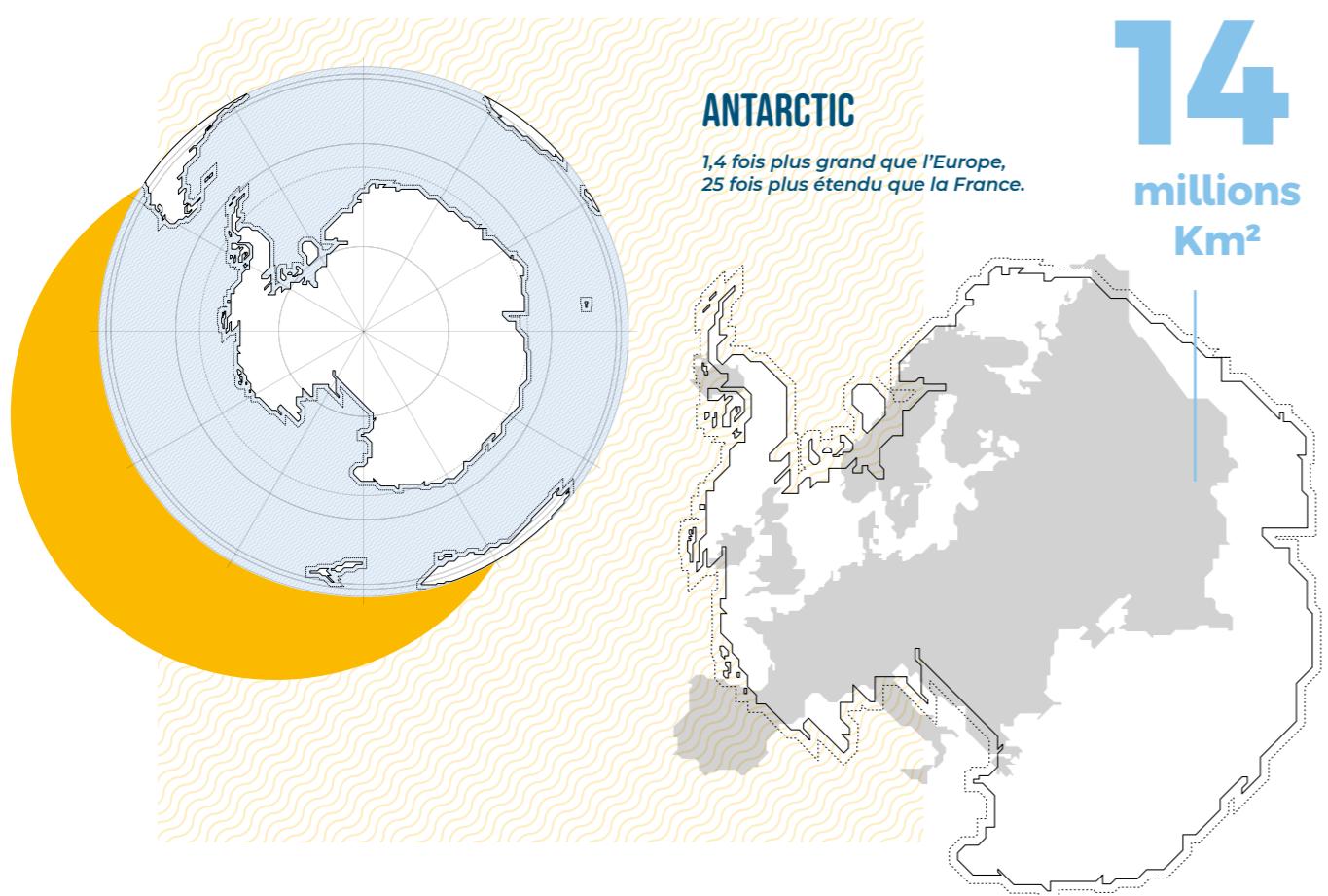
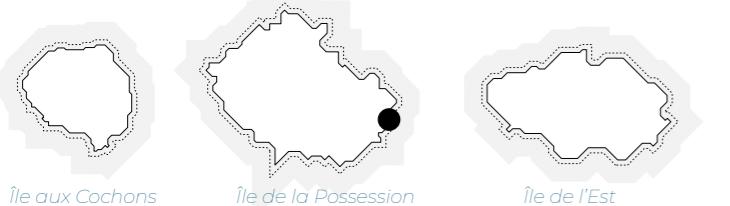
Let's start with the high points, the ones that will remain in the Institute's history because, fortunately, memories are selective and tend to remember the positive. The spotlight is on the research projects, the "raison d'être" of the Institute that supports them. Among the ongoing 74 projects and 108 field campaigns in the various Arctic, Subantarctic and Antarctic regions, three of them, which much more ambitious than usual, were implemented in the southern hemisphere this fiscal year. First we have the French-Norwegian PALAS 2 project in the Subantarctic area, which plans to collect sediment cores in several lakes that are quite difficult to access, located in the western sector of the Kerguelen Islands. Second, in Antarctica, glaciology took centre stage with the setting up of a core drilling camp at the Little Dome C site (located roughly 40 km from the Concordia station) for the new European Beyond EPICA project. And third, the EAIST scientific traverse into the unexplored sector separating Concordia from the South Pole.

In addition, one of the high points of this past fiscal year was to have been able to bring the Minister of Research, Frédérique Vidal, as well as the CEO of the CNRS, Antoine Petit, to discover the mythical white continent and some of our infrastructures. This was a first for a Minister in charge as well as for the head of the flagship of French research. On this occasion, an action plan was discussed in favour of research, infrastructures and national logistics at the poles. I hope that this will become a reality in the coming months because the Institute is currently understaffed, placing a burden on French aspirations. 2019 was also a year of internal and external initiatives. A few examples of this include: the development of a 'Forward-looking management of jobs and skills' solution and a review of the functionality of the Institute, the creation of an innovation department that made it possible to initiate numerous industrial contacts as well as to launch the Institute's 'Carbon footprint©' programme (a first for a polar operator), the application of the new graphic charter and the creation of new institutional films, in addition to the management of the Archipôles national archives platform, the establishment of a bilateral scientific committee for Concordia as well as a tripartite managerial committee with the European Space Agency, and the organization of the general assembly of the European Polar Board in Brest.

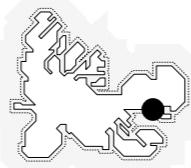
The main setback was the damage caused to the L'Astrolabe, discovered by the ship - the French Navy - in mid-November 2019 when it was leaving Hobart in Tasmania to carry out its first mission to support our Antarctic logistics. The ship ended up being sent to an Australian shipyard for repairs, and we are grateful to the Australians who

stepped in and saved the Polar Institute's campaign and our two Antarctic stations at the same time: our counterparts from the Australian Antarctic Division agreed, at a moment's notice, to provide their own icebreaker to ensure the supply run, delaying their own campaign by two weeks. A tremendous display of solidarity among polar operators! The fact that the collateral damage caused by this technical mishap was as limited as possible is also due to our highly skilled operational teams: they were able to reorganize several hundred tons of freight within a few hours, they immediately changed the routes for personnel, they organized three lightning-fast rotations for the Astrolabe in the second half of the season once the ship had been repaired, etc. However, international solidarity and the skills of our agents were not enough. Against this exceptional background, the Polar Institute fortunately had its fair share of good luck with the exceptionally good weather and sea ice conditions during the stopovers at Dumont d'Urville. Obviously, this is not something that can be counted on each year.

In June 2021, France will chair the annual meeting of the Antarctic Treaty in Paris, 32 years after the last time. It is my personal hope that with this geopolitical perspective, we will be able to collectively inspire a new national momentum in favour of research in polar environments. Anyone who reads the following pages should be convinced that this is a necessity because France should be very proud of the work we're carrying out there. As it stands, in the words of former minister Hervé Gaymard, France will not remain a 'polar power' unless our decision-markers engage in strong and long-lasting commitments.

**SUBANTARCTIC ISLANDS****ARCHIPEL DE CROZET****Base Alfred Faure**

46°25'S - 51°51'E
934 m d'altitude (Pic du Mascarin)
1^{er} hivernage en 1962
Environ 25 hivernants
et jusqu'à 50 personnes en été

**ARCHIPEL DE KERGUELEN****Station de Port-aux-Français**

48°27' - 50°00 S. 60°27' - 70°35'E
1800 m d'altitude (Mont Ross)
1^{er} hivernage en 1949
Environ 50 hivernants
et jusqu'à 100 personnes l'été

ÎLES AMSTERDAM ET SAINT PAUL**Base Martin-de-Viviès**

37°50'S - 77°32'
881 m d'altitude (Mont de la Dives)
1^{er} hivernage en 1950
Environ 25 hivernants
et jusqu'à 50 personnes en été

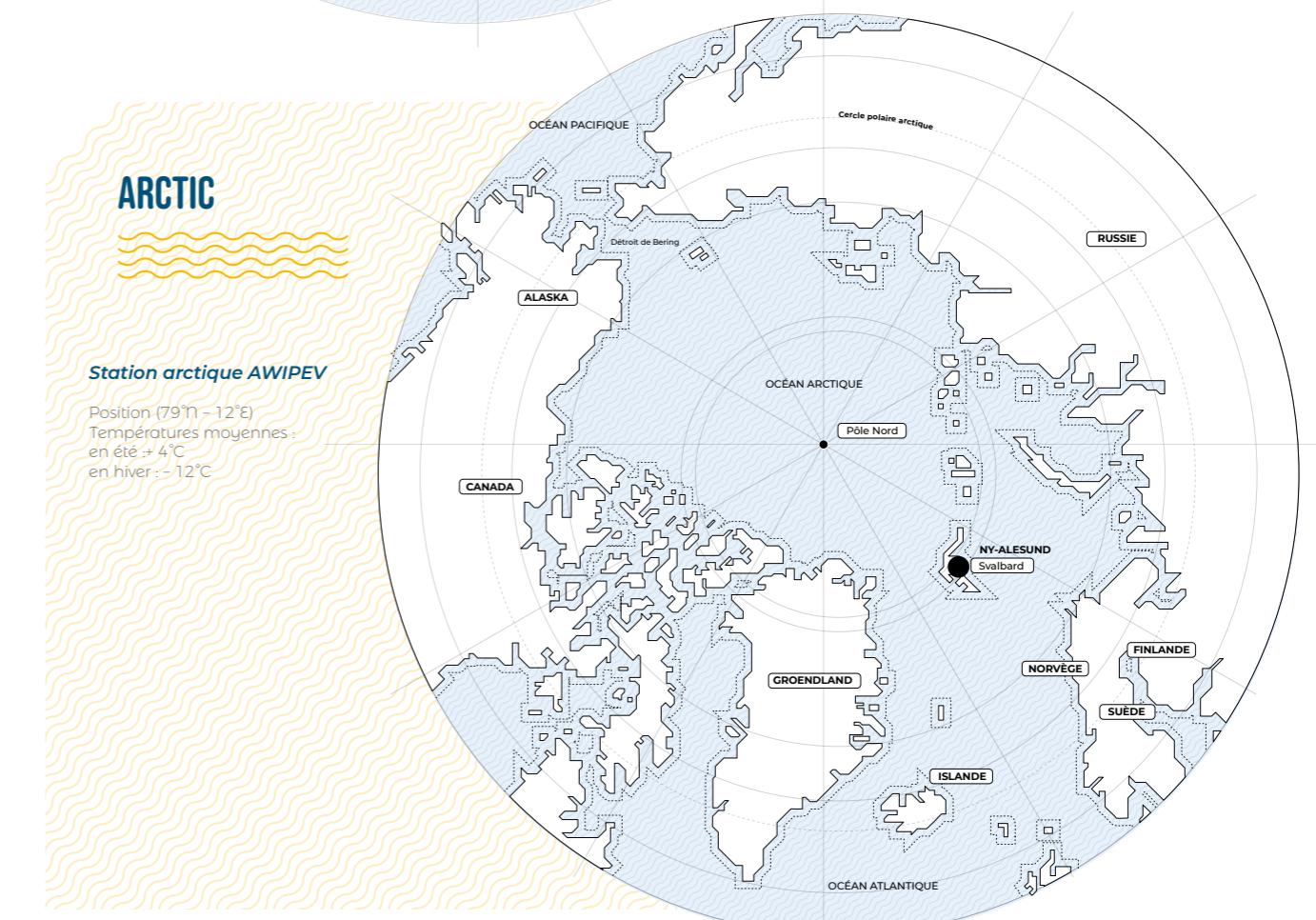
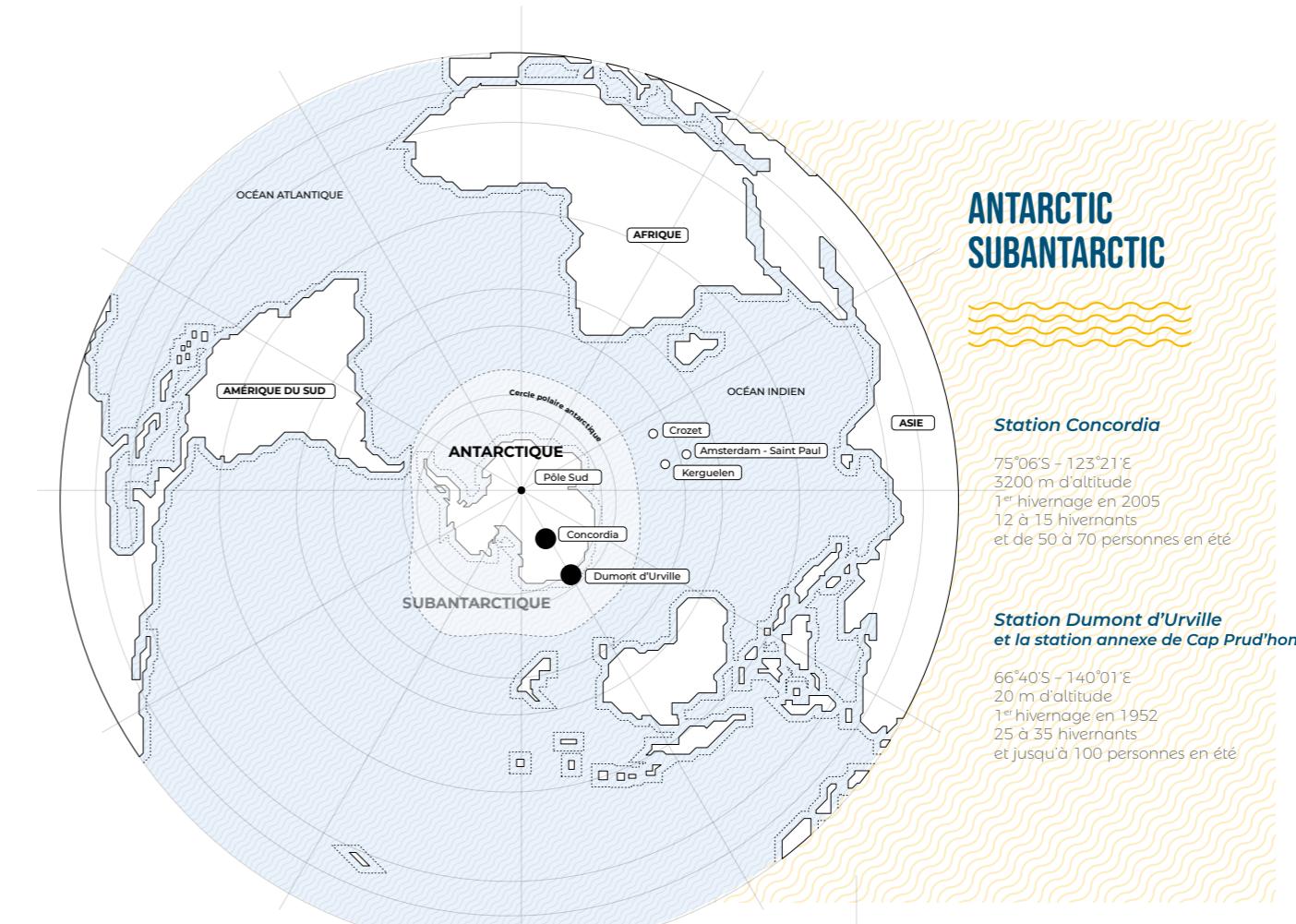


TABLE OF CONTENTS



10

A YEAR IN THE FIELD

P. 11 LOGISTIC IN ARCTIC
P. 12 LOGISTIC IN ANTARCTIC
P. 14 LOGISTIC IN SUBANTARCTIC



18

SCIENCE

P. 20 PALAS
P. 34 EAIIIST



46

BACKGROUND INFORMATION

P. 48 MISSIONS
P. 50 DATA



52

PARTNER

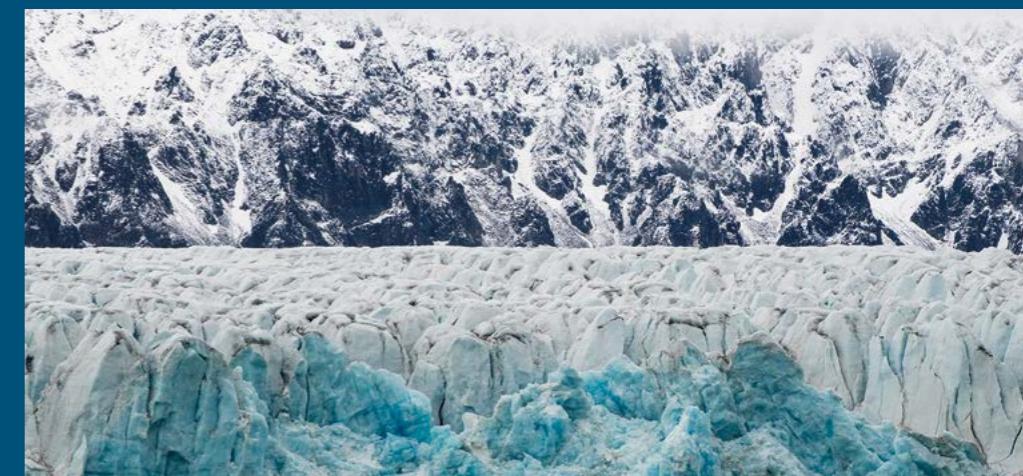
P. 54 AUSTRALIAN ANTARCTIC
DIVISION



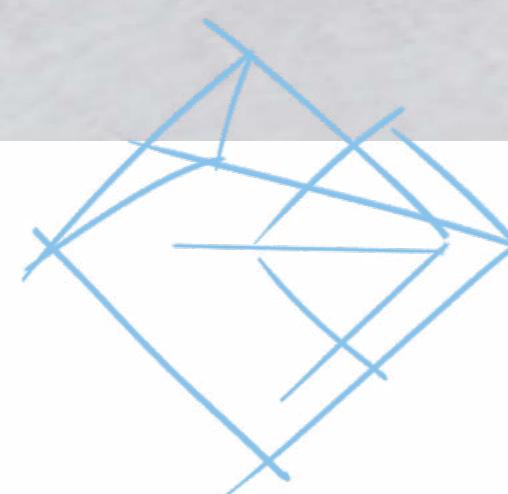
56

SCIENTIFIC PROGRAMMES SUPTED

P. 58 SCIENTIFIC
PROGRAMMES SUPTED
IN ARCTIC
P. 79 SCIENTIFIC PROGRAMMES
SUPPORTED IN ANTARCTIC AND
SUBANTARCTIC ISLANDS



A year in the Field



SUPPORT FOR SCIENTIFIC PROJECTS

The Institute provided support for 10 French scientific projects in marine biology, ornithology, glaciology, ionospheric science and atmospheric physical chemistry.

Installation of the electric winch on the *Jean Floc'h* vessel:

The winch and hydraulic crane on the *Jean Floc'h* are quite often used for all operations at sea. This combination is very practical for putting somewhat heavy loads to sea, but lacks flexibility and speed for small sensors or light sampling systems. As it has already been shown that the electric winch on AWIPEV's second boat is perfect for this use, the same model was installed on the *Jean Floc'h*. As a result, we now have two winches and a more suitable profile speed for the body of water. The lower units of the outboard engines were brought back at the end of the season for a complete overhaul by a professional in Brest.



Installation of a stabilization ballast on the Goupil electric vehicle:



After a few years of use of this vehicle, the Goupil has a better grip on the ice and snow when loaded. As a result, ballast was placed on the chassis of the vehicle to improve passenger safety during use.

Installation of a compressed air system in the scooter garage workshop:

The general mechanical workshop called the 'scooter garage' now has a compressed air system equipped with a 150L compressor (to clean mechanical parts, inflate tyres, etc.). It also has a bench grinder and a welding machine (TIG steel/stainless steel/aluminium and coated electrodes).



Installation of a new load regulation system for the Corbel wind turbine

In 2018, a new wind turbine was installed at the Corbel station. It worked for several months on the old battery electric charging regulation system. But at the beginning of this year, the system broke down. Therefore, a new charging system was purchased from the manufacturer of the wind turbine and installed during the fall campaign.

Creation of a special window and installation of a staircase

This year, the researchers wanted to install scientific equipment to measure the auroral radiation at the Corbel station. Given that this equipment is very sensitive to stray light (extraneous light), the Corbel site in winter is an ideal location as there is no light pollution. In order to install this equipment, a window had to be created in the laboratory/workshop building. It is tilted towards the sky and has optical quality glass with an anti-frost system.

An external staircase was also manufactured so as to be able to reach the roof platform safely in order to take a series of measurements using the 360° instrument.

Author

Dominique FLEURY

SCIENTIFIC AND TECHNICAL ACTIVITIES IN ANTARCTICA

At the start of the season, this 2019-2020 summer campaign was generally characterized by good environmental conditions with mild weather and negotiable pack ice less than 35 km from Dumont d'Urville. The first air arrivals to Dumont d'Urville and Dome C landed on the agreed-upon dates, 2-8 November, which meant that the stations could be opened and the EAIIST and logistics traverses were able to depart on time.

However, the weather changed for the worse starting in January with 16 days of snowfall, two times the normal seasonal values, making it much more dangerous to carry out all of the operations.

The major difficulty encountered this season was the damage to the submerged bearings of the *Astrolabe*'s shaft lines right before the first rotation (R0). This breakdown had a long-lasting impact on the summer campaign and meant that all arrivals and departures as well as logistical and technical provisional schedules had to be reorganized.

Fortunately, the chartering of the polar vessel *Aurora Australis* on December 11 to Dumont d'Urville and the three express rotations of the repaired *Astrolabe* organized between late January and early February made it possible to deliver the priority cargo, i.e. food, spare parts, fuel and the essential fluids needed to maintain the stations.

In addition to the impact on the scientific programmes, the damage to the *Astrolabe* resulted in significant repercussions on several logistical and technical positions.

With regards to energy, it was not possible to deliver 300 m³ of SAB fuel (Special Antarctic Blend, the fuel used in Antarctica). Stations will still be able to be self-sufficient up until early January 2021, however the safety stock was not built up. There was a shortage of 30 m³ of aircraft fuel, i.e. the overall supply contained 23% less fuel. One of the direct results of this shortfall this season was that the Icemap airborne project was discontinued in order to save energy. And last, 50% of the fuel supply for the vehicles could not be delivered. Broadly speaking, all of the stations' SAB fuel safety stocks were used to cover the consequences of the *Astrolabe* damage.

With regards to the work projects, the repair of the Concordia supply store and the work on the southern helipad field camp had to be postponed because the equipment could not be delivered. Because the equipment needed to



Aurora Australis unloading on sea ice

repair the cladding on machinery hangar No. 57 at Dumont d'Urville was only delivered during R4, this project had to be postponed. In addition, work on the Prud'homme store (covering it with cladding), was also postponed until later in the season.

Following the cancellation of R0, and thus the arrival of the scientific personnel, the technical team had to help out with the scientific work during the month of November and in early December. As a result, certain work projects were slowed down.

The handover between inbound and outbound wintering personnel took place in one and a half days instead of 7 days (the average). Certain more specific handovers requiring more time (telecommunication-radio, glaciology, power plant), which normally take place over a one-month period, did not happen. This meant that the handover of the necessary information needed for the incoming team was less efficient. This made it more difficult for incoming personnel to take up the post and the on-site handover (polar environment) was limited.

The Institute operated with the new helicopter company (Canadian Helicopters - HNZ) that won the tender last year. A helicopter was on-site throughout the entire season and a second machine arrived with the *Aurora Australis* vessel to facilitate the unloading as well as the R4 rotation. The collaboration with this company is highly satisfactory and it was shown that the investment in the company's equipment was worthwhile.

Authors

Gaëlle SELLIN, Doris THUILLIER

DUMONT D'URVILLE REPAIR/IMPROVEMENT WORKS AND LOGISTICS

Despite the delay in deliveries, it was possible to carry out repair work at the station and at Cap Prud'homme using materials that had been delivered during the previous campaign. The main project was to completely cover the spare parts store for the Cap Prud'homme traverse.

The campaign also included numerous projects that were smaller in scope but still quite important as they ensured the proper technical management of the site: the sides of building 25 laboratory No. 1 were covered, the boiler room in building 31 living room-recreation room was renovated, the tunnel under the road used to pass pipes and electric cables was replaced in the southern end of Pétrels Island.

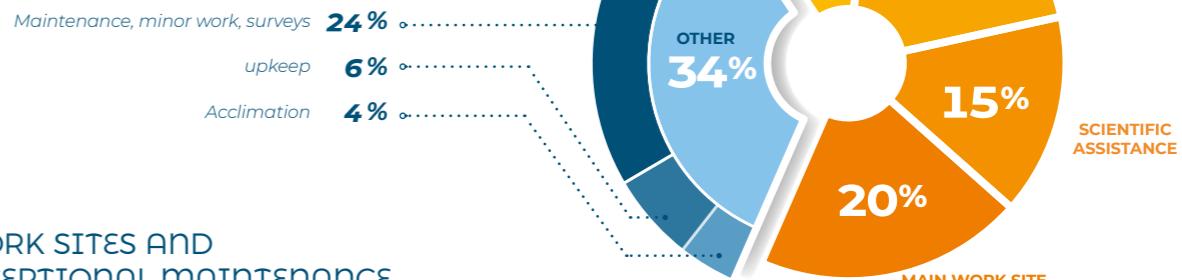
TRAVERSE: DUMONT D'URVILLE/ CONCORDIA CONVOYS

Despite the disruptions during this season, the 5 logistical and scientific traverses (EAIIST, Samba) left on time. It was possible to carry out the planned maintenance or specific projects, such as covering the exterior of the store with cladding.

Although the temperatures were relatively high, adverse weather affected air links with delays up to 10 days at times.

FRENCH-ITALIAN CONCORDIA STATION SEASONAL OVERVIEW

The technical office's missions are divided between ensuring the handover to incoming overwintering personnel, facility maintenance and upkeep, logistics (reception, dispatch, handling, distribution and storage of packages), assisting scientific operations and overseeing work sites and new work projects.



WORK SITES AND EXCEPTIONAL MAINTENANCE

Some of the first major projects of the year were to repair the flat base of the noisy tower, to overhaul the grey water treatment unit (GWTU) and to cover the exterior of the general store with cladding.

Overall, the work carried out to support scientific programmes went very well. Collaboration between the scientific coordination and the technical coordination beforehand, as well as in the field, made it possible to synchronize and smooth the workload.

A major challenge was to provide assistance to the Beyond Epica (BEOI) project, which took up more than half of the technician time allocated to science.



LOGISTICS IN THE SUBANTARCTIC ISLANDS

The main mission of the French Polar Institute in the southern islands is to ensure the scientific and logistical organization for the winter camps and summer campaigns. Due to weather conditions, these field missions are deployed between the months of November and March.

DELIVERING SUPPLIES TO THE FIELD CAMPS

Specifically, the French Polar Institute provides supplies and maintenance to the field camps, 50 potential sites, where scientists and civic service volunteers stay throughout the year. Primarily helicopters and barges are used to drop off scientific materials, food and equipment at the sites.

In 2019, supplies were delivered via helicopter during the Marion Dufresne's November and December rotations. Scientific equipment and tools (logistics) are recovered during the March-April rotation (OPI).

By the end, the logistics team from the French Polar Institute replenished the food, energy and scientific equipment supplies at the following field camps and isolated sites:

CROZET: La Pérouse, Baie américaine, Pointe basse
KERQUELEN: Pointe Suzanne, Estacade, Ratmanoff, Pointe Morne, Val Studer, Baie Charrier, Cap Noir, Cap Cotter, Cataracts, Sourcils noirs, Phonolite, Bossière, Port Elisabeth, Gazelle, Port Couvreux. Mortadelle and the 6 isolated sites of the PALAS project (north of Kerguelen)

AMSTERDAM: Entrecasteaux and Del Cano



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Estacade field camp

WORK PROJECTS AT REMOTE SITES

CROZET

During the 2019 campaign, a logistics team was deployed to carry out a renovation project at the Pointe Basse field camp. The main objective of the project was to repair the ageing parts of the structure so as to ensure the safety of users and the durability of the structure in particular. The most important part involved reinforcing the structure of the raft foundation, which supports the field camps, and the traffic zones. The storage and work spaces in the red French Arbec Hut, located next to the field camp, were reorganized, maximizing the available space.

The Baie Américaine field camp was inventoried this year in anticipation of a renovation project in the next few years. However, some improvements were made such as temporarily securing the awning and routine maintenance, as well as sorting out and fully cleaning the field camp.



Pointe Morne field camp



Restoration of the raft foundation for the Studer field camp

KERQUELEN

The interior of the Estacade field camp has been renovated so that a team of 4 scientists can live there over long periods of time with, in particular, the installation of solar panels so that the field camp is now self-sufficient in energy. In addition, the field camp was furnished with 4 beds, a kitchenette and a workshop for scientific activities.

The Pointe Morne field camp was completely renovated with the installation of exterior cladding over the entire refuge and the installation of a new roof. Rainwater collection systems and autonomous photovoltaic solar systems were also installed.

Continuation of the multiannual project at the Studer field camp: after having thoroughly cleaned up this site, which dates back to the 1980s, and furnishing the inside with sleeping and storage fixtures, major work was carried out to solidify the foundations and to maintain the field camp.

The old scientific workshop at the Île Verte field camp was demolished and fully cleaned up. A new module was brought to the island by helicopter and set up by the logistics team.

Workshop for the Île Verte field camp



The Korrigan Field camp was prepared for winter because there are no plans for personnel to overwinter there in 2020.

The two Fillods (prefabricated metal constructions) for the Mortadelle field camp were given a waterproof coating in order to make the field camp permanent. The weather station was inspected by civic service volunteers from the Polar Institute's IT department and data were sent for an IGE science project.

On the nearby glacier, the forward base for the Mortadelle field camp was dismantled and then evacuated during Marion-Dufresne's OP1 (port operation 1) because it was no longer in use.

New remote sites were established so that scientific projects could be set up on new sites:

For the Palas scientific project (see insert below), a total of 6 drop-off sites for scientific and living equipment were used: 5 wooden living and sleeping modules, 5 wooden sleeping and storage boxes and 4 tents and coring equipment.

For Talisker, a camp with 2 modules that can be transported by helicopter was positioned in the northern Presqu'ile de la société de Géographie area.



Port Cenis field camp

WORK SITES AT THE STATIONS

CROZET, ALFRED FAURE

The main activity of the Polar Institute teams is still to provide

support for science projects during the summer campaign. Specific maintenance projects are also being carried out to upkeep the base's logistical and scientific structures.

This year, a team was sent to the Crozet station to start reorganizing the Biomar laboratory in order to make it more operational and functional.

The Science de l'Univers field camp has now been freed up with the transfer of the servers to Biomar. This room is now being used as a long-term storage area for logistics and scientific equipment.

KERGUELEN, PORT AUX FRANÇAIS

The B17 logistics platform of the French Polar Institute at the Port-aux-Français station received a new roof and by moving and re-installing the equipment it was possible to tidy up, sort and reorganize the workshop.

For the Palas project, in addition to ordering the large modules, 2 small storage modules were manufactured in wooden box format to be transported by helicopter.

SUPPORTS AND SPECIFIC MEANS OF SUPPORT FOR SCIENTIFIC ACTIVITY:

Over the past few years, in a joint charter with TAAF, the Polar Institute has been deploying a 25 m vessel, La Curieuse, to carry out both scientific projects and prospecting activities and to maintain remote coastal sites over the entire Kerguelen district.

This year, La Curieuse enabled numerous scientific missions to be carried out around Kerguelen. The vessel was on-site during the first period of the year from January 1 to January 24 and then from November 26 to December 31, 2019.

It ensured a security support mission for the Palas mission and enabled the deployment of the land missions across Kerguelen for the Enviker, Bingo, Talisker, Cycleleph, Salmevol, Subanteco projects as well as the monitoring of the marine environment with the Proteker project which involves scuba diving around Kerguelen and in the Gulf of Morbihan.

As part of the ten-year maintenance plan for the Superdarn Project, a certified observation project, an 18 m articulated boom lift was installed in 2019 and enabled the scientific teams to carry out the rejuvenation plan and guarantee the operational continuity of this tool.

Guymer Site



PALAS 2 PROJECT:

During this 2019 campaign, the logistics team set up the Paleoclimate from Lake sediments on Kerguelen Archipelago 2 (Palas 2) project in the northern part of the Kerguelen Archipelago. The objective was to collect lake sediment samples in order to reconstruct past climatic fluctuations at high resolution.

Its deployment around the glacier lakes in the northern area of Kerguelen required a substantial logistical investment on a scale that has never been seen in the past two decades!

- A self-sufficient mission was set up for a team of 8 scientists comprised of 4 French and 4 Norwegians over a period of one month. In order to guarantee the safety of the mission, new communication procedures were used with GPS allowing messages to be sent even if there is no network coverage.

- New field camps were installed at 6 remote sites near the lakes selected to carry out lake coring operations. These field camps were built, furnished and then temporarily set up on site for the duration of the mission.

In total, the logistics (field camps, food, energy, etc.) and scientific (coring barge, sonar, etc.) equipment weighed 17 tonnes: 31 helicopter loads. This required the exceptional deployment of a B3-type Écureuil (or Squirrel) helicopter for the recovery.

In particular, the main difficulty of this operation was that there was only a very short operational window available to install the personnel, samples and equipment during OP3, and then to recover everyone and everything during OP4 over a large geographical area: Approximately 3 days of helicopter time (roughly 10 hours/day) were needed: 1.5 days for drop-off + 1.5 days for recovery. This duration is equivalent to or greater than that needed to deploy an operation at Crozet or Amsterdam, all operations combined (TAAF, French Polar Institute, Nature Reserve) during the Marion Dufresne's supply rotations. A lot of preparation was needed beforehand between the scientific and logistics team to complete this project.

IT WAS POSSIBLE TO COLLECT SAMPLES FROM THE 6 SELECTED LAKES IN UNDER ONE MONTH OF THE CAMPAIGN. THIS REPRESENTS 14 SAMPLING POINTS FOR A TOTAL OF MORE THAN 120 METERS OF SEDIMENT CORES.

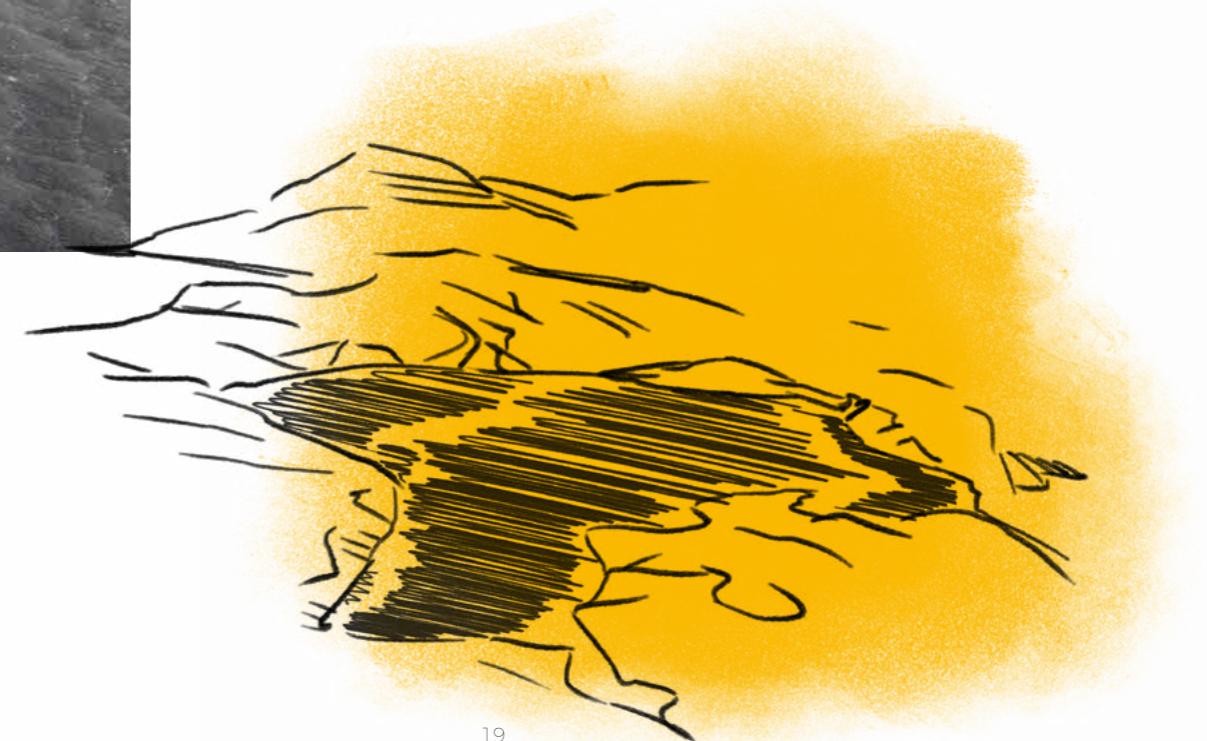


Science



MISSION
PALAS 2 20
PALAECLIMATE FROM LAKE SEDIMENTS
ON THE KERGUELEN ARCHIPELAGO

EAIIST 34
EAST ANTARCTIC INTERNATIONAL ICE SHEET TRAVERSE



mission PALAS 2019

PALAECLIMATE FROM LAKE SEDIMENTS
ON THE KERGUELEN ARCHIPELAGO

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ABSTRACT

The Kerguelen Archipelago is located in the Southern Hemisphere westerly wind belt (SWW), which plays a critical role in regulating the Earth's climate system. Almost as large as Corsica, it is characterized by numerous glacial lakes. Sediments deposited at the bottom of these lakes constitute valuable records of past climatic and environmental changes. During the PALAS 2019 field work, sediments found in six of these lakes, located between the Cook Ice Cap and the Presqu'île de la Société de Géographie, were cored. Using cores measuring 5 to 10 m long, we hope to cover several thousand years of history in these environments. Glacial landforms close to the lakes were also mapped and sampled. As part of the 'Southsphere' project, led by Jostein Bakke from the University of Bergen (Norway), 'classic' sedimentological and geochemical analyses will be performed on the cores. Emerging methods, such as 3D tomography, analyses of lake sediment DNA or even temperature-dependent bacterial membrane lipid compounds will also be used. Cosmogenic isotopes from the rock samples will be used to date moraines, erratic boulders and roches moutonnées. This set of unprecedented results can be used to reconstruct the glacier fluctuations during the Holocene and the climatic changes that controlled them, which are still poorly known in this very remote region.

flour

Glacial flours are composed of fine clayey particles that are formed by glacial abrasion on rock surfaces.

Cosmogenic

Cosmogenic isotopes are formed when high-energy cosmic radiation interacts with atomic nuclei. They are produced in the atmosphere and, in some cases, in rocks and soils exposed to this radiation.

INTRODUCTION

The Kerguelen Archipelago is located at 49°S, i.e. in the Antarctic Polar Front Zone which separates the cold polar waters from the temperate waters of the Subantarctic regions. Today, this zone, also known as the 'Antarctic Convergence', oscillates between a latitude of 48° and 61° depending on the season. It is characterized by very strong westerly winds that are found in the northern hemisphere. In the southern hemisphere, these winds are particularly violent given that there are no continents to slow them down (Figure 1). Navigators call these strong winds the famous 'roaring forties' and 'furious fifties'; for climatologists, they require special study because of the essential role they play in regulating the Earth's climate. They isolate Antarctica from the warmth of the lower latitudes, stimulate global ocean circulation via the Antarctic circumpolar current (ACC) system and regulate the absorption of CO₂ in the Southern Ocean. This position in the Antarctic Convergence Zone makes the Kerguelen Islands a key site for understanding the global climate system and its evolution.

Even though this band of latitudes plays a major role in regulating the climate on a global scale, we have very limited knowledge about past climate changes. This is explained by the high proportion of ocean compared to continents, making it difficult to acquire climate records. A few records have been obtained via marine cores, as well as from continental records, primarily in Patagonia followed by Tasmania, New Zealand and South Georgia¹. In the French Southern and Antarctic Lands (TAAF), the first studies on the continental records are quite recent. At Amsterdam, for example, analysis of the flux and origin of dust trapped in peat has made it possible to reconstruct the past dynamics of westerly winds over the past 6,600 years. In particular, it highlights alternating phases of strengthening and/or shifting winds towards the equator and phases of weakening and/or shifting winds towards the poles². A study carried out on the geomorphology of glaciers on Kerguelen have allowed us to track major glacier fluctuations over the past 24,000 years³. In addition, using a modelling approach (integrating instrumental data from the Port-aux-Français station), this same team showed that the poleward shift towards the polar front, which

resulted in decreased precipitation on Kerguelen, explained to a large extent the dramatic retreat of the Cook Ice Cap since the 1960s⁴. Thus, there is a relationship between polar front fluctuations and the westerly winds, and the fluctuations of the Kerguelen glaciers, via precipitation.

The PALAS 2019 mission was designed to improve our knowledge about past glacial and climatic fluctuations in this region of the world. To do this, the goal was to collect as many lake sediment records in connection with the Cook Ice Cap as possible (Figure 2), so as to be able to indirectly study (i.e. via glacial processes) the dynamics of the westerly winds. Lakes fed by glaciers have a high potential for recording the glacial signal over time, since a large part of their sedimentation comes from the production of glacial flour⁵. In order to validate these reconstructions and to better constrain them in space, the moraines and other glacial landforms around the lakes were mapped and sampled during the mission for cosmogenic isotope dating purposes.



Figure 1. Illustration of the atmospheric circulation (source : Nasa) :
the changes in circulation over time can be viewed here :
<https://svs.gsfc.nasa.gov/3723>

¹ Dätwyler et al., 2018; Fletcher et Moreno, 2011; Kilian et Lamy, 2012; Oppedal et al., 2018; Saunders et al., 2012; Shulmeister et al., 2004

² Li et al., 2020

³ Jomelli et al., 2017

⁴ Favier et al., 2016

⁵ Nesje et al., 1991

Furthermore, to determine the role of temperature and precipitation in the Cook Ice Cap fluctuations, a multi-indicator approach will be used on cores as part of the 'Southsphere' project, led by Jostein Bakke from the University of Bergen (Norway). The target indicators are hydrogen isotopes for tracking precipitation and lipid biomarkers for temperature. Sedimentological and geochemical analyses will be used to track glacier fluctuations. Analyses will also be performed on terrestrial plant remains, pollen and plant DNA to study fluctuations in plant cover, in terms of extent and composition, in relation to climate change. If exotic pollens are found, they can be used as indicators of changes in the position of the westerly winds. Finally, at Lake Cartographie (Figure 2), around which a large number of rabbits could be observed during the mission, it is planned to carry out DNA analyses of mammals and plants in order to track the dynamics of invasive species and their impact on the environment in this area which is actually quite far from their point of introduction.

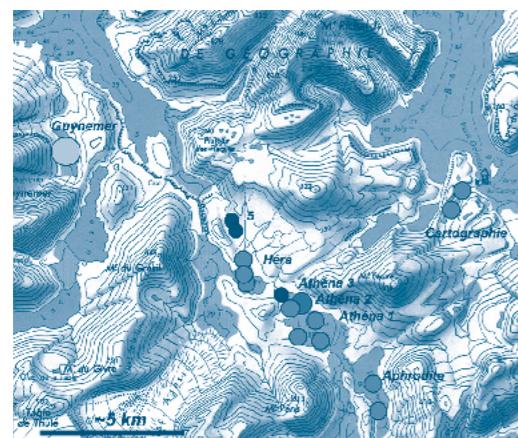


Figure 2. Distribution of the coring sites and lengths of the core sampled during the PALAS 2019 mission.

Figure 3. Illustration of the applied coring techniques.

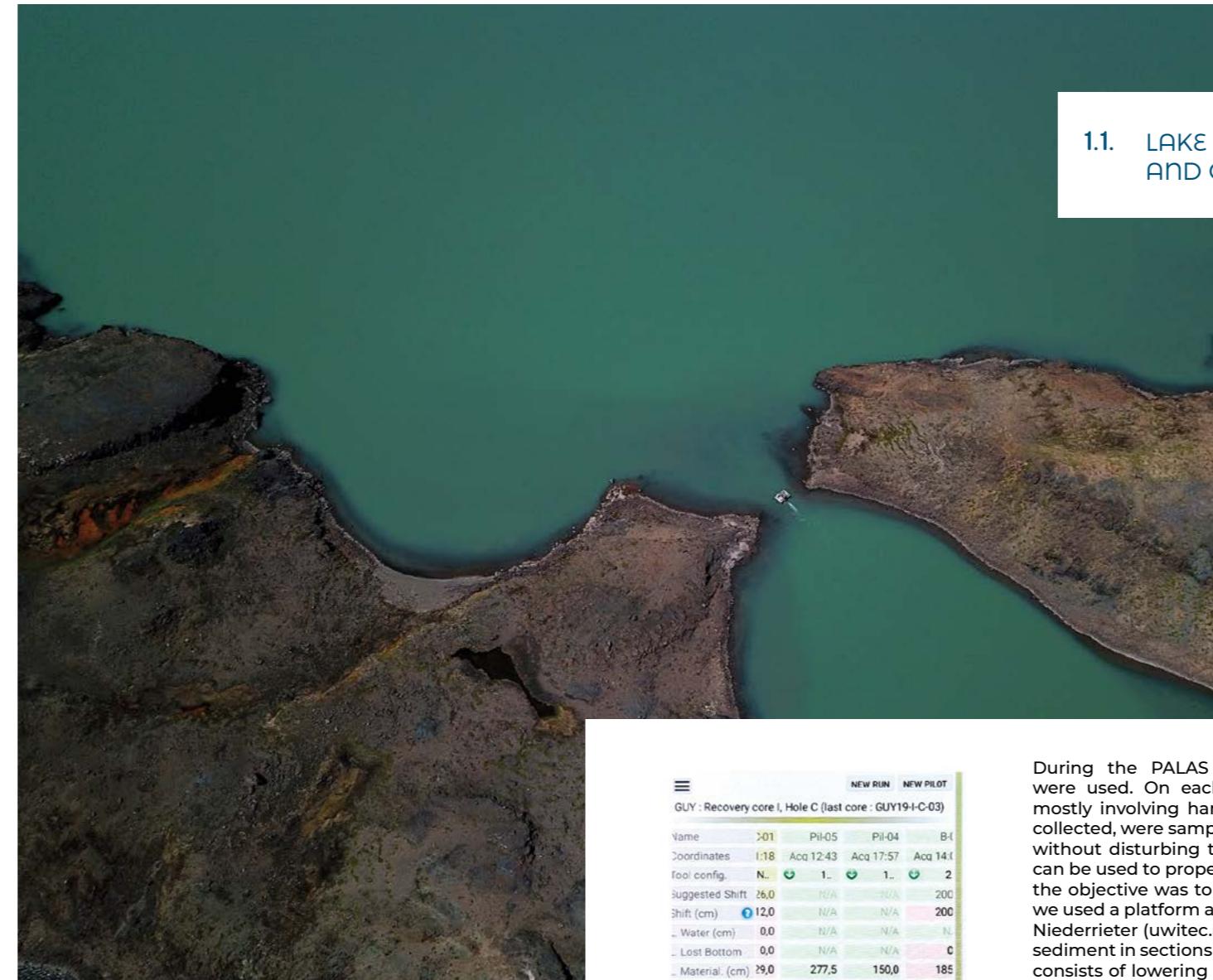
A) Photos of the coring platform used at Guyemer and one of the core samples collected using the Nesje corer. The corer diagram illustrates the piston corer system developed by Niederrieter and used at Guyemer as well as Athena to collect cores > 6 m long (in sections measuring 2 or 3 m).

B) Core diagram provided by the Corebook application. When this application is used in the field, it is possible to enter the coordinates of the cores and to mark the position of each section in real time. This makes it possible to assess how much sediment is lost and thereby helps the person sampling the cores to obtain the entire sediment infilling sequence (i.e. a recovery rate of 100% between the sections).

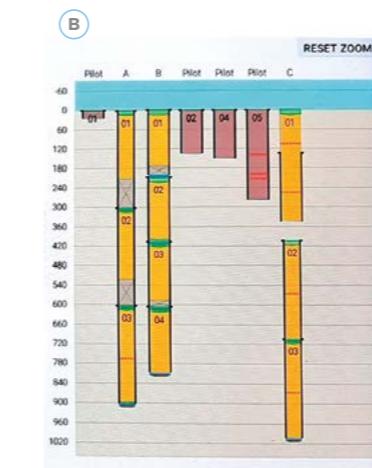
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biomarkers

Lipid biomarkers are specific organic molecules that can be used to identify the origin of organic matter.



NEW RUN NEW PILOT			
GUY : Recovery core I, Hole C (last core : GUY19-I-C-03)			
Name	X01	Pil-05	Pil-04
Coordinates	I:18	Acq 12:43	Acq 17:57
Tool config.	N	1-	1-
Suggested Shift	26,0	N/A	N/A
Shift (cm)	12,0	N/A	N/A
Water (cm)	0,0	N/A	N/A
Lost Bottom	0,0	N/A	N/A
Material. (cm)	29,0	277,5	150,0
Cap to cap	30,0	282,0	154,0
Top Material.	14,0	N/A	N/A
Bottom Mat.	43,0	N/A	N/A
Bottom Liner	43,0	N/A	N/A
Bottom Run	43,0	N/A	N/A
Piston (cm)	14,0	N/A	N/A
Corer-Catcher Samp.	□	□	□



1. METHODS

1.1. LAKE BATHYMETRY, SEDIMENTARY INFILLINGS AND CORE ASSESSMENT

In order to determine the zone(s) where sediment core samples will be taken, it is necessary to know the lake bathymetry. In addition to the morphology of the lake basin, it could be interesting to determine the thickness of the sedimentary infilling and to study how the deposits are organized. In order to do this, sedimentologists use seismic reflection equipment which, through the various propagation speeds of the waves based on the materials encountered, makes it possible to show the layers of sediment. Palaeo-environmentalists/climatologists often prefer the deeper, flat and remote areas of deltas. In fact, these areas are the least affected by sublacustrine landslide deposits coming from the slopes of the basin. These instantaneous deposits may be quite thick and may have eroded some of the previous deposits. In addition, these areas have reduced sediment accumulations, which allows to maximize the temporal depth covered by the record.

During the PALAS 2019 mission, three different core drilling techniques were used. On each of the lakes, 'short' gravity cores (UWITEC core drill), mostly involving hammering so as to increase the thickness of the sediment collected, were sampled. This coring technique is used to take sediment samples without disturbing the interface and therefore provides essential records that can be used to properly document the recent sedimentation. In Lake Guyemer, the objective was to sample the longest sequence possible. In order to do this, we used a platform and an UWITEC stationary piston corer developed by Richard Niederrieter (uwitec.at). This type of corer (Figure 3A) can be used to sample the sediment in sections measuring 2 (90 mm Ø) or 3 m long (63 mm Ø). The principle consists of lowering the corer from the platform to the desired depth and then locking the piston in order to be able to start the coring by hitting it using hammers. Once the 2 or 3 m tube is filled with sediment, the corer is raised to the surface using winches and the core is recovered. Then, the corer is sent 2 or 3 m further down in order to sample the next section and so on. A hydraulic core catcher system or an orange peel is installed at the base of the corer to prevent the loss of sediment while raising the core. Even if these systems work correctly, sediment corresponding to the space taken by the stationary piston is lost between each section. In order to make up for this loss and obtain 100% of the sedimentary sequence, a second core(Hole B, Figure 3B), offset in depth, is sampled right next to the first (Hole A). The core diagram is built in real time in the field using the Corebook application developed at the EDYTEM Laboratory (Figure 3B). The third coring system used is the one developed by Atle Nesje⁶. This is also a stationary piston system that is used to collect samples by hammering up to 6 m of sediment at once. It has been used in all of the lakes.



1.2. GEOMORPHOLOGICAL MAPPING AND SAMPLES TAKEN FOR DATING ANALYSES

MAPPING

Past glacier extensions are identified through a combination of observations and the mapping of glacial landforms and formations. Observations are carried out at several spatial and temporal scales. Prior to the field mission, satellite imagery is used to perform these observations. Since 2017, the resolution of the images available on Google Earth have been satisfactory, however the easternmost part of our study area (Guynermer Peak) is completely whited-out because it is covered by an image from August 2006. This resource made it possible to identify several moraines that have been there for a while but only recently became more visible, especially in the Guynermer sector. Given the cloudy and snowy conditions in this region, we only acquired Pléiades tri-stereo coverage on January 16, 2019, almost one year after it was ordered from Airbus DS as part of the ISIS programme (Access to SPOT images for Science/Incitation à l'utilisation Scientifique des Images SPOT). Thus, from this perspective, the postponement of the PALAS mission by one year to the 2019 OP3 was welcomed: the DEM (digital elevation model) and orthophotography produced from these satellite images helped us with our preliminary observations for the mission. Numerous moraines were identified, as well as areas with roches moutonnées with their abundant erratic boulders, and potential glacial drainage channels, which helped guide the organization of the field mission. Given that

this area does not have any footpaths whatsoever and is also characterized by numerous rivers that cannot be crossed on foot, these images were used to identify possible routes in the field. In fact, this geomatic resource formed the basis of the Geographic Information System (GIS) in which the field observations were reported daily as a geomorphological map (see Inset 1) — which also incorporated very high-resolution images acquired by drone in several sectors.

The goal of geomorphological mapping is to create a spatial reconstruction of the Holocene or even Tardiglacial glacial extensions⁷. The frontal and lateral moraines illustrate the 2D geometry of the glacier (and its temporal variations). It was possible to model the volume of this glacier from this geometry as well as from the derived glaciological parameters — therefore, the altitude of the glacial equilibrium line and its evolution are palaeoclimatic indicators. Arches moutonnées sector indicates minimal extension of the glacier in terms of length and altitude; an erratic boulder, one position of the glacier during a retreat phase.

DEM

 The DEM (Digital Elevation Model) is a representation of topography. Orthophotos are images of the earth's surface (satellite or aerial) whose geometry has been rectified so that they can be superimposed on a flat map.

⁷Jomelli et al., 2017

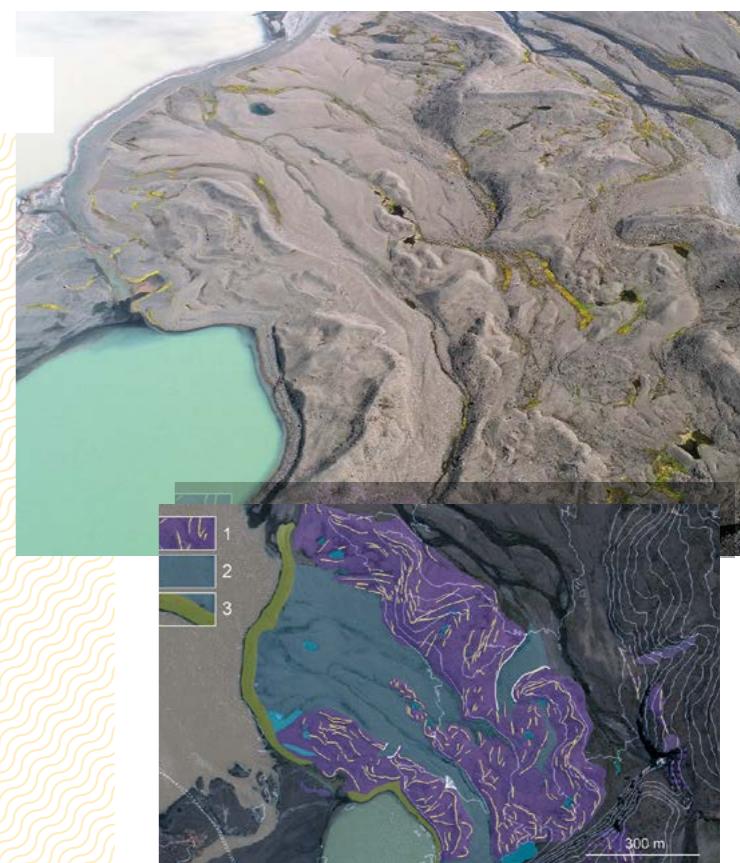
Inset 1.

GEOMORPHOLOGICAL MAPPING

The principle of this mapping is to represent all landforms (e.g. moraine, scree, etc.) and formations (e.g. till, glacial-lacustrine infilling, etc.) found within a study sector, by associating them to the processes that generated them (e.g. glacial, periglacial processes, etc.) while integrating the chronology (at least relative) of their establishment.

The topic of our study explains that emphasis was placed on geomorphological markers of glacial dynamics — only a few non-glacial forms/formations have been mapped when they can be used to recognize/identify glacial forms (e.g. gullying and associated deposition affecting a moraine, or an abutting rockfall deposit).

This figure shows part of the moraine complex of the Agassiz glacier. Three sets of moraines can be distinguished in the photo taken by the drone (top; authorization 2019-158). By cross-checking satellite (bottom) and drone images with field observations and photos, it was possible to map these moraines in detail as seen by the large number of ridges (N.B.: the moraines are not listed in order based on their sizes). The footprint and distribution of the wide drainage channels provide evidence for the extensive reworkings that have affected this moraine complex on at least two occasions. The wind fetch induced by the size of the lakes, which see frequent and intense winds, and the seasonal variations in their water level explain the development of beaches on their shores.



1: moraine and moraine ridge ; 2: drainage channels ;
 3 : lake beach (N.B. : the other represented landforms are not explained here). The dotted white line indicates the position of the glacier front in 1963.
 Isohypse contour interval: 50 m
 Orthophoto: Pléiades satellite, 16/01/2019



dendrochronology

 Dendrochronology is a dating method based on counting and analysing the morphology of growth rings in trees.

fetch

 Fetch is the time and unobstructed distance travelled by wind over a body of water. At the end of this 'momentum' zone, the water will rise to form a wave: the greater the fetch, the higher the wave.

SAMPLES COLLECTED FOR COSMOGENIC DATING

This spatial dimension of the palaeo-glaciation shown by the map must be combined with a relative and absolute chronometric calibration. In most mountain massifs, the presence of wood layers in the moraines has made it possible to establish chronologies for the glacial fluctuations using dendrochronology and radiocarbon dating⁸. As there are no trees on Kerguelen, dating using in situ cosmogenic isotope (see Inset 2) products was used⁹ (see Inset 2). For this, samples were taken from the moraine complexes, in areas with roches moutonnées and on erratic boulders. It will also be possible to use these dates to track the past dynamics of the various glaciers (Guynemer, Agassiz and Chamonix).

In total, two glacial deposits, 10 roches moutonnées surfaces, 23 erratic boulders and 75 boulders on moraines were sampled using an angle-grinder and a hammer and chisel (Figure 4). These 110 samples, weighing 1 to 2 kg, were collected from basalts (100), in which ^{36}Cl is produced from calcite, and from quartz veins and geodes (10) in order to measure the ^{10}Be concentration.

Inset 2.

DATING BY IN SITU-PRODUCED COSMOGENIC ISOTOPES

Primary cosmic radiation interacts with components of the atmosphere creating cosmogenic nuclides which then adsorb onto the surface of the minerals in the rocks, resulting in nuclear reactions. As a result, cosmogenic nuclides (^{14}C , ^{26}Al , ^{36}Cl , ^{10}Be) then start to be produced there, in situ. The measurement of their concentration provides an estimate of how long the rocky surface has been exposed, taking into account the nuclide production rate (which depends on time, altitude, etc.), the local topography (shielding) and the rate of possible erosion of this surface. Cosmogenic nuclide surface exposure dating requires collecting samples with a maximum thickness of 3-5 cm, preferably at the centre of large flat boulders or on the ridge for moraines, and as stable as possible, and recording their dimensions, their altitude and the topographic shielding (Figure 4). The sample then undergoes mechanical preparation followed by geochemical preparation in the laboratory, which takes a long time for ^{10}Be : the steps include grinding and sieving, purification, separation and dissolution with hydrofluoric acid (HF), then substitution of HF and, last, beryllium oxide (BeO) extraction — a much faster preparation for ^{36}Cl . The isotope ratio can then be measured by Accelerator Mass Spectrometry (AMS), in France, on the national ASTER instrument (LN2C, CEREGE). This ratio is then converted into a concentration, from which an exposure age is calculated using an online calculator, along with an uncertainty (analytical and on the production rate) that is generally < 5% except for very young surfaces (past few centuries).



Figure 4. Collecting basalt samples for surface exposure dating using ^{36}Cl : a: collecting samples on an erratic boulder located in the upper western flats of the Guynemer Basin (325 m altitude); b: sample Ker 1991 collected from a boulder on lateral-frontal moraine Ma-1 (the outermost) of the Agassiz complex (70 m); c: shielding sample and measurement on a boulder on frontal moraine Ma-3 of the Agassiz complex (75 m); d: sample taken from a roche moutonnée on Mont Fauve (515 m).

2. RESULTS

2.1. BATHYMETRY AND SEDIMENTARY INFILLING

The bathymetry of Lake Guynemer is relatively simple as there is a single basin that is quite deep (90 m). Conversely, the bathymetry of Lake Hera and the other Mythos lakes is much more complex as they are made up of several basins and sometimes contain 'hummocky' structures that can be seen on the seismic profiles (Figure 5A). This complexity is probably related to sediment inputs from the various glaciers (Agassiz, Chamonix and Pointu) connected to the lakes in the past and to subaqueous slides. Within this sedimentary context, we understand why seismic equipment is needed to identify the most appropriate coring areas, i.e. areas with undisturbed sedimentation (preservation of the chronological order of the deposits and without hiatus), and thus to be able to address our scientific question.

2.2. OVERVIEW OF THE SAMPLES, FIRST RESULTS AND OUTLOOK

At Guynemer Lake, 10 m of sediments in 3 m-long sections and from 3 holes (A, B and C) were collected (Figure 3B). In addition, three other cores measuring 1.40 to 2.90 m in length were collected using the Nesje coring system. The cores will be studied in Bergen and Chambéry starting in June 2020. However, it was already possible to make a few observations. As an example, approximately fifteen centimetres of well-preserved and laminated sedimentation was brought up on the anchors used to stabilize the core drilling platform when the anchors were removed (Figure 6). These sediments clearly show a colour change marking a recent change in the type of sedimentation. In the southern anchor, at the foot of the delta formed by glacial inputs from Guynemer Peak (1088 m), it was possible to observe a deposit that had slid and rolled up on itself, something that is typical of sub-lacustrine landslide sediments. At the other end of the lake, an atypical deposit containing high amounts of plant debris was also observed in the sediments brought up with the anchor, whereas the water depth (80 m) is too shallow for the in situ development of aquatic plants. Future studies will enable researchers to

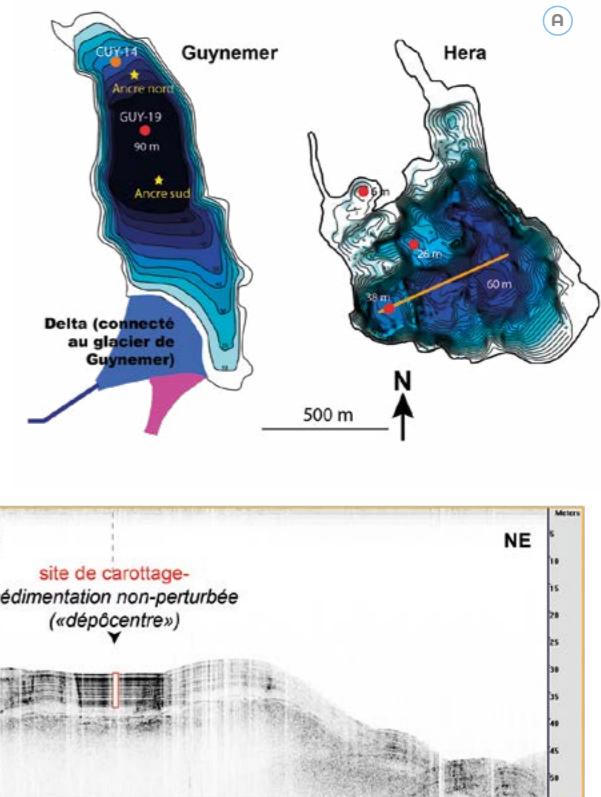


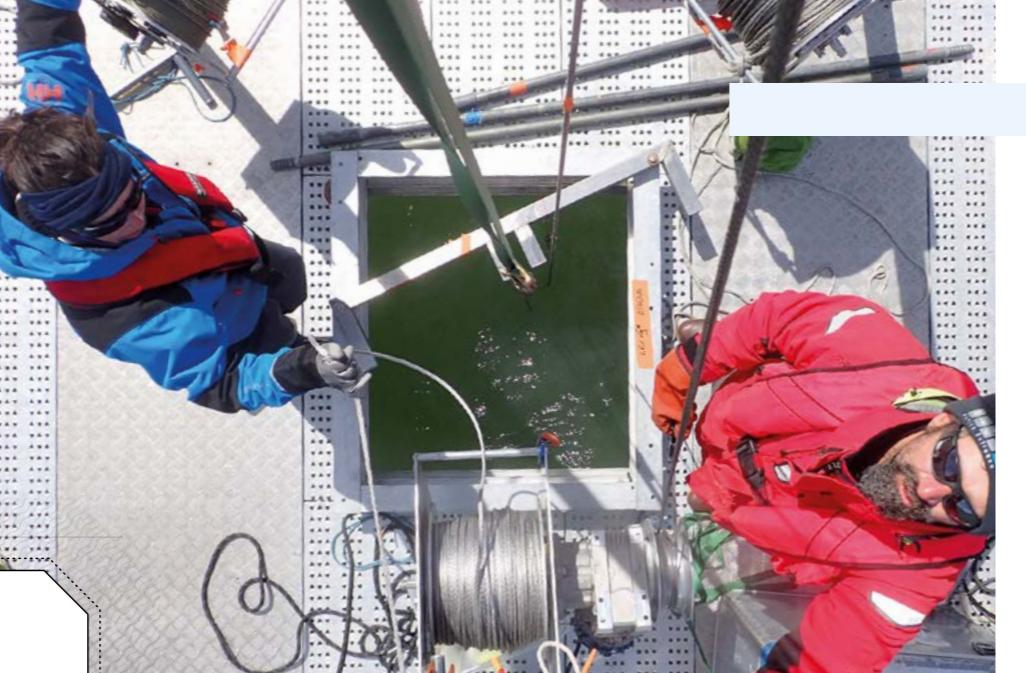
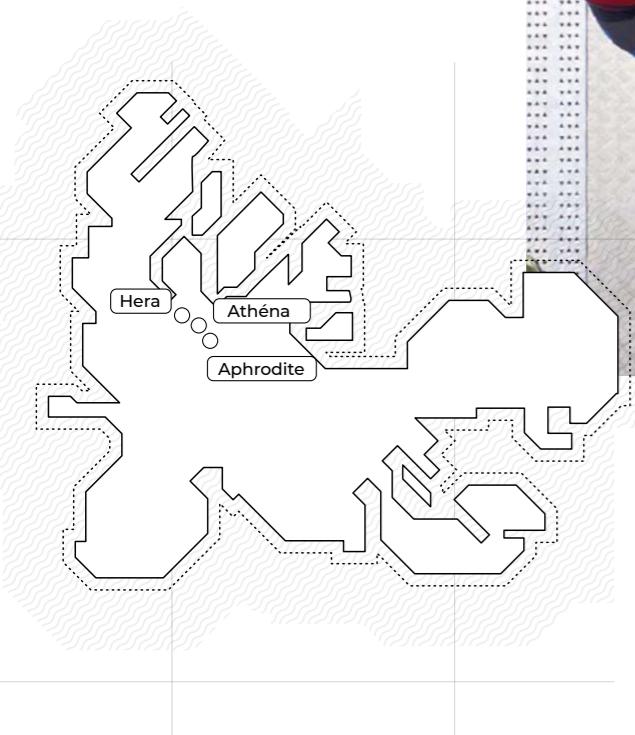
Figure 5. Bathymetry and seismic profile.
A) Bathymetric maps of Guynemer Lake and Lake Hera illustrating the various underwater topographies encountered on the lakes located north of the Cook Ice Cap. The 2014 and 2019 coring areas are indicated by orange and red dots, respectively. The positions of the north and south anchors, installed to stabilize the platform during coring, are indicated by yellow stars. B) Seismic profile corresponding to the SU-NE transect in orange on the bathymetric map of Hera. In particular, it highlights a small perched basin with undisturbed sedimentation (unlike the deeper zone) and in which a 6 m core was sampled using a Nesje corer (Nesje, 1992). In the northeastern part of the transect, 'hummocky' structures appear.

determine if these deposits are synchronous and to determine their origin. One hypothesis could be that an earthquake triggered a destabilization in the aquatic part of the delta, causing a tsunami at the other end of the lake. Such evidence of recent seismic activity would be an important discovery, as Kerguelen is not known to be a very seismically active area. This would complement a recent study carried out by our team, which studied sediments from Lake Armor and found deposits linked to 8 major volcanic eruptions that took place on the Rallier du Baty Peninsula over the past 11,000 years¹⁰.

⁸e.g., Le Roy et al., 2015

⁹e.g., Le Roy et al., 2017

¹⁰<https://eartharxiv.org/5jnu6/>



On the so-called 'Mythos' lakes (i.e. Héra, Athéna, 5 and Aphrodite) and one of the 'Cartographie' lakes (Figure 2), cores measuring 5 to 6 m long were collected using the Nesje system. At Athena 2, a 7 m-long core was also taken with the Nesje system up to 6 m long and then with the 'Niederrieter' system up to 7 m long. A total of 14 sites were cored on the six lakes, representing a total of 127 m of cores (Figure 2). Among other analyses, lake sediment DNA analyses will be performed to track past climate changes. They will also make it possible to address palaeoecological questions such as the interactions between an invasive species, the rabbit, and the environment (see: Inset 3).

As with all records, dating analyses are essential in order to obtain palaeoclimatic and palaeoecological reconstructions. For lake sediments spanning several thousand years, the main step is based on radiocarbon (¹⁴C) analyses of plant macro-remains. However, in glacial environments, it can be difficult to find plant remains in the cores. Chronologies of volcanic eruptions, recently established by our team using sediments from Lake Armor¹¹, could be used to provide additional dating information.

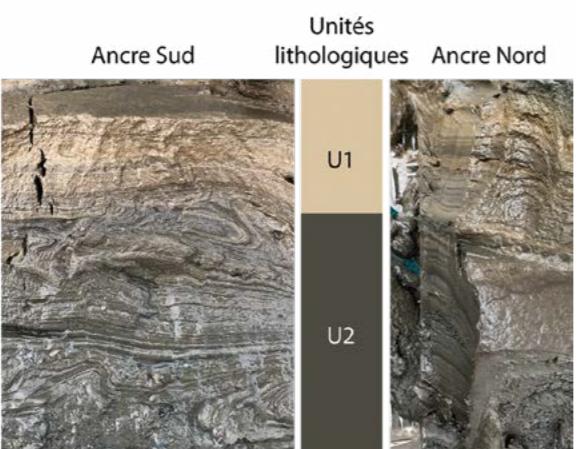
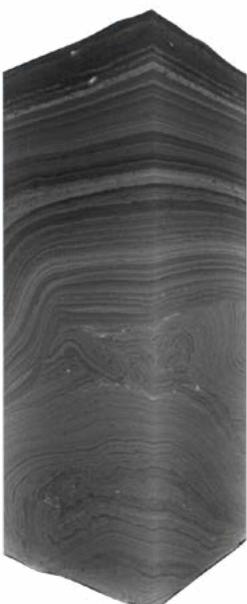


Figure 6. Illustration of the sedimentation in Lake Guynemer.
The left part of the figure shows a 3-dimensional tomographic image (CT-scan) of the sediment core collected from the anchor located on the southside of the lake. It highlights denser clay sediments (in black), less dense silts and sands (in white) and highlights the 3-dimensional deformations caused by a subaqueous slide. The right part shows photos taken in the field of the sediments brought up from the south and north anchors and their division into lithological units.

¹¹ Arnaud et al., 2020

Inset 3.

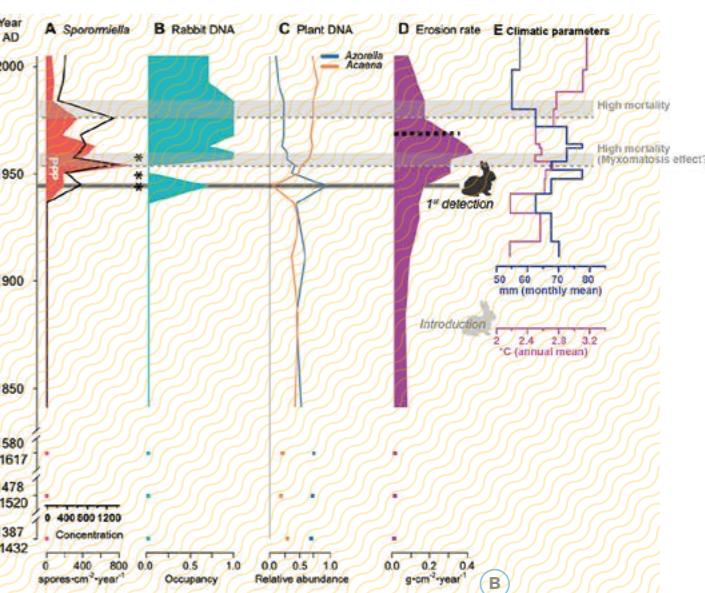
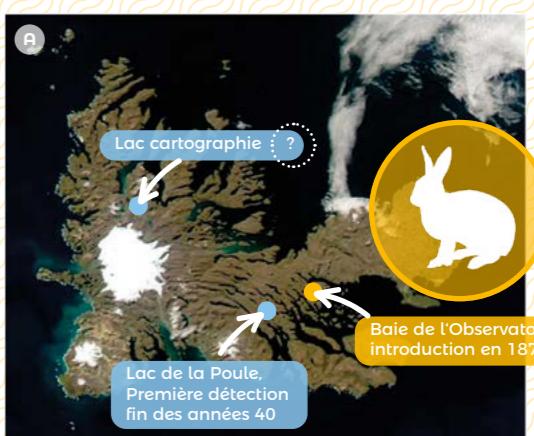
HISTORY OF THE RABBIT INVASION ON KERGUELEN AND ECOLOGICAL IMPACT

Rabbits were introduced to Observatory Bay in 1874 by British navigators from the HMS Volage. This was done in order to ensure a food resource on this mammal-free island, especially in the event of a shipwreck. The introduction was successful in the sense that the rabbits proliferated. However, it also resulted in a major ecological crisis. During the subsequent scientific missions, the very first signs of this crisis were seen on the endemic flora, with the almost-complete disappearance of the Kerguelen cabbage (*Pringlea antiscorbutica*), followed by the replacement of the Azorella Selago carpets with *Acaena Magellanica*, and then the effect of plant cover degradation on soil erosion. Even though the impacts of the introduction of this invasive species have been described many times, we still only have limited knowledge about the temporal dynamics of the invasion and ecosystem responses. Lake sediment records are the only way to go back in time to retrace these dynamics.

During the previous PALAS mission in 2014, sediments from a core sample taken from Lac de la Poule were subjected to plant and mammal DNA analyses (Fig. A). These analyses have made it possible to pinpoint the arrival of rabbits in the watershed towards the late 1940s, i.e. approximately 70 years after they were introduced on the island, roughly ten kilometres away as the crow flies (Fig. B). This presence is confirmed by the observation of coprophilic fungi spores (*Sporomiella* sp.) that grow on herbivore faeces. The rabbit invasion very quickly caused an erosion crisis that lasted until the mid-1960s. Although erosion has become less of a problem since the 1960s, the change in the plant community, i.e. the gradual disappearance of Azorella in favour of *Acaena*, still exists today. Given that the Azorella population started to decline as soon as the rabbits arrived can most likely be explained by the massive degradation of these cushion plants due to the construction of burrows (and then the rains could easily move the plant fragments). In the mid-1950s, the high rabbit mortality suggested by the data (decreased sporomella concentration and DNA spike due to cadavers), may reflect the introduction of myxomatosis in 1955-1956.¹². A second phase of significant mortality was recorded in 1975. This could have been caused by the virus, decreased food resources or another reason. It is interesting to note that the decrease in erosion occurs before this significant decline in the rabbit population, but it is concurrent with the decrease in precipitation. The erosion crisis observed when the rabbits arrived could also have been exacerbated by the increase in rainfall (Fig. B).

Around Guynemer Lake and the Mythos lakes, only a few living or dead rabbits were observed during our PALAS 2019 mission. Kerguelen cabbage is still relatively abundant there and so are Azorella cushions. However, near the Cartographies lakes or on the coast of the Baie du Repos, further away from the Cook Ice Cap,

we were able to observe large rabbit populations. How long did it take for the rabbits to colonize this very remote area of Observatory Bay? What is the scale of the impact on erosion and vegetation? What are the temporal dynamics of the responses of the ecosystem as well as the rabbit populations (are we in a phase of decline as around Lac de La Poule?)? The use of DNA analyses on the sediments of Lake Cartographie will provide answers to these questions.



A) Location 1) the lakes targeted to study the rabbit invasion and its effects on the ecosystem (in yellow) and 2) Observatory Bay where the rabbits were introduced (in red).

B) Temporal evolution of Sporomiella spores (A), rabbit DNA (B), Acaena and Azorella (C) and the rate of erosion in the sediment core from Lac de La Poule Lake (D)¹³. The curves (E) represent the changes in temperature (annual average) and precipitation (monthly average) since 1912 (interpolated using data collected from weather stations worldwide from the University of Delaware¹⁴).

¹¹ Chappuis et al., 1995

¹² Ficetola et al., 2017

¹³ Nickl et al., 2014





2.3. MAPPING THE MORAINES AND TAKING SAMPLES FOR DATING: PRELIMINARY RESULTS ON THE GUYNEMER PROGLACIAL MARGIN

The current Guynemer Glacier is divided into four unequal parts, with a total surface area close to 1.4 km^2 . The two lower sectors (0.25 km^2) are found 100 to 250 m below the upper sectors from which they are separated by non-glaciated walls; their fronts descend to an altitude of 340 and 395 m.

The part of the Guynemer moraine complex located upstream from the cone-delta is quite complex: in addition to the three main lateral-frontal moraines (Mg-4 to 6) downstream from the upper lake, between which less-continuous ridges are found, numerous ridges surround this lake, especially on its north shore, marking the glacial retreat since 1963; the inner flank of the largest of these moraines, the visible part of which overlooks the 30 m lake, is subject to active runoff (Figure 7a). A few perched ridges $> 300 \text{ m}$ on the south shore are possibly connected to the Mg4-6 set.

Three moraines are present around the lower Lake Guynemer: Mg-3 on the intermediate bench on the west shore, between 165 and 200 m in altitude, Mg-2 at its northern end, a few m above the lake, and Mg-1 on a bench on the east shore, at an altitude of 190 m.

Forty samples were collected to carry out cosmogenic dating on Mg-1 (2), Mg-2 (3), Mg-3 (3), Mg-4 (7), Mg-5 (8), Mg-6 (5) and on 12 erratic boulders distributed at various altitudes (max: 305 m) around the lower lake including at the limit, at an altitude of 150 m, between Lake Louise and Guynemer Lake.

The same mapping and sampling approach was applied in the proglacial margins of Agassiz (Figure 7b) and Chamonix. Samples were also taken from roches moutonnées and boulders along a 500 m altitudinal transect between Lake Athena 2 and the summit of Mont Fauve (Figures 2 and 7c). This work will help document the extension phases of the Agassiz and Chamonix glaciers.

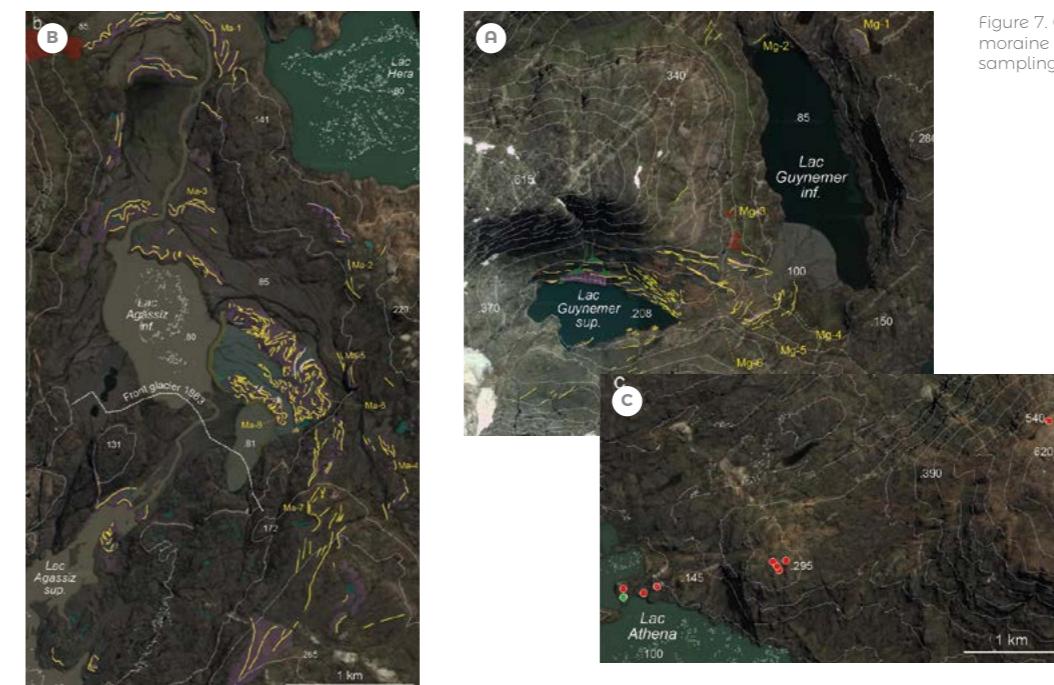


Figure 7. Guynemer (a) and Agassiz (b) moraine complexes, and Mont Fauve sampling transect (c).

CONCLUSION

The work of the five core cutters and three geomorphologists during a one month period in the field and the logistics put in place by the French Polar Institute meant that an incredible amount of samples could be collected: 127 m of sediment and 110 rock fragments.

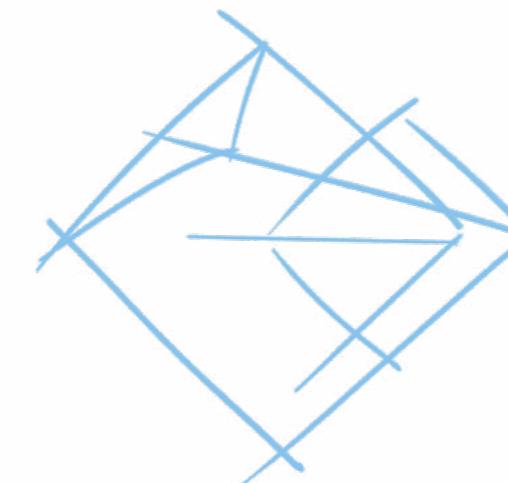
The preliminary results of this mission have already resulted in a map of the glacial formations in the study area, located between the Cook Ice Cap and the Presqu'ile de la Société de Géographie. The first analyses performed on two short cores from Lake Guynemer already show recent changes in the sedimentation dynamics and raise questions about the potential recording of seismic activity linked to volcanism. Answers to these questions will be found by dating these cores. Cosmogenic isotope analyses to date the ice formations are currently underway and the study on the remaining cores will begin in June 2020. Therefore, we will soon have the reconstructions of the glacier and palaeoclimatic fluctuations.

ACKNOWLEDGEMENTS

The entire PALAS team would like to thank the Polar Institute as the PALAS 2019 campaign simply could not have even been imagined without it. In particular, the subantarctic logistics team provided us with support from the very start in the design stage of the campaign. The professionalism and total dedication of the Institute in the field, in the name of science, undoubtedly made possible what seemed to many people as impossible.

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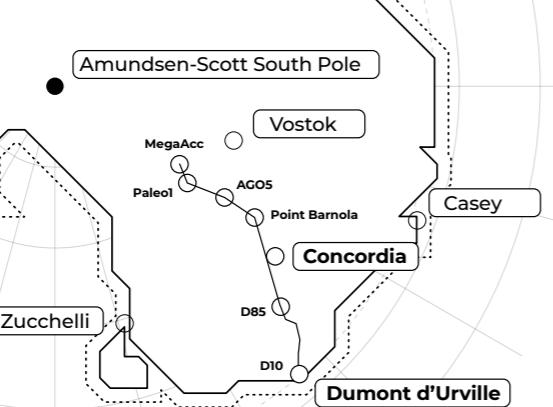
EAIIST

East Antarctic International Ice Sheet Traverse

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INTRODUCTION

A SHORT AND RATHER INCOMPLETE HISTORY OF LAND TRAVERSSES IN ANTARCTICA.

was the incomparable Ernest Henry Shackleton. The aim of the 1914 Imperial Trans-Antarctic Expedition – better known as Endurance, the ship that was swallowed up by pack ice – was to make a crossing of Antarctica from the Weddell Sea to the Ross Sea via the South Pole. Shackleton's crew used dog sleds and counted on the support of a second logistics team deployed in the Ross Sea, whose mission was to lay depots for the last leg of the journey. This they did, although three members of the team died.

Honour where honour is due. The first person to have ever envisioned, designed, organised and attempted a land traverse on continental Antarctica

All 'Polar' people know the incredible story of the Endurance, this epic monument to survival in a hostile polar environment, and the unbelievable crossing by boat between the inhospitable and ice-covered Elephant Island and South Georgia. This journey was a feat (an inspiring story of survival under Shackleton's command) within a failure (the Antarctic crossing itself never took place).

It was almost fifty years later and during the third International Polar Year (1957-1958) that the first overland traverse of the Antarctic continent would take place over 99 days and 3500 km. The British explorer Vivian Fuchs and his team set out from the Weddell Sea on Tucker Sno-Cat and Bombardier Muskeg vehicles and became the first to cross Antarctica. Their support team was led by the illustrious Sir Edmund Hillary, who mapped out the final section of the journey between the Ross Sea and the South Pole.

Two years later, after overwintering at Charcot station in 1957, the French glaciologist Claude Lorius – invited by an American team for the Victoria Land Traverse – carried out a mechanised traverse and co-discovered a mountain range that was not mentioned in the topographical surveys of the time. On the strength of his polar experience, Claude Lorius pioneered the International Antarctic Glaciological Project (IAGP) with Russian, American, Australian and British colleagues. This glaciology programme, which ran from 1969 to 1980, aimed to study and understand the history, evolution, flow, surface and bedrock topography of the East Antarctic polar ice cap through overland traverses and airborne soundings¹. This programme was the first to use overland traverses as a research rather than an exploration tool, with a complete scientific programme including geodesy, geophysics, seismology, analysis of the physical and chemical properties of ice, and a drilling programme. The data acquired during the IAGP determined, among other things, the location of the deep drill holes at D47 and Dome C (drilling Dome C 78, EPICA) and consequently the location of the Concordia research station.

Many traverses followed, not all of which will be detailed here, but it is worth noting that 10 years after the end of the IAGP programme, the International Trans-Antarctic Scientific Expedition (ITASE) initiative was relaunched in France, Grenoble, bringing together 20 nations. This international programme, which lasted until 2010, enabled several scientific traverses to be carried out that aimed to spatialize climatic, meteorological, geophysical and chemical data.

It is within the ITASE framework that France resumed scientific traverses. With the benefit of 20 years of experience in logistical traverses supplying the Concordia research station and following the renewal of part of its vehicle fleet, the French Polar Institute Paul-Emile Victor (IPEV) had gained new capacities for scientific traverses. It now had, 30 years after the IAGP programme, a life caravan, energy caravan, mobile laboratories and sleds. This means that since 2010, scientists have been able to carry out scientific traverses such as the VANISH programme (Concordia-Vostok round trip traverse), ABN (French-Australian Dumont d'Urville-Aurora Basin North traverse) or ASUMA (coastal traverse around Dumont d'Urville). All have more or less followed an identical scientific programme close to IAGP's recommendations. A scientific traverse, although less expensive than an oceanographic or airborne campaign, still represents a considerable financial cost, so everyone strives to maximize the scientific experience gained in order to make the most of the investment. The EAIIST traverse of the 2019-2020 summer campaign was not immune to this constraint. Here is the story.

PREPARATIONS

CONSTRUCTION PHASE OF THE PROJECT AND FINANCING



In line with previous projects and in the absence of surface data on a section of Dome C-South Pole, which corresponds to the shift in the ice flow towards the western part of Antarctica, the idea arose to conduct a scientific traverse in this section. While visiting McMurdo station in 2012, I spoke with the then director of the National Science Foundation's (NSF) glaciology programme, Julie Palais, to see what she thought about a Dome C-South Pole traverse in collaboration with American teams. With her encouragement, the first contacts were established with Italian and American teams and later with Australian researchers.

A first workshop was organised in Grenoble in September 2014, followed by the drafting of a white paper which included scientific questions, participants, route, financial plan and a planned timetable. Given the distances to be covered in a two-month traverse, this journey (3300 km round trip) could only be completed in two seasons: Dome C-South Pole in year n with winter storage of vehicles at the South Pole and the return journey in year n+1. This set-up was the best match for the distance that needed to be covered, with the double benefit of crossing specific topographic structures such as megadunes or 'glazed' surfaces, and it enabled us to set up a series of experiments on the visited sites that could be recovered the following year when returning to Concordia. Therefore, logistical support was needed (fuel, winter storage of vehicles, maintenance) from the South Pole station. Unfortunately, a major difficulty that is common in this type of project very quickly emerged: coordinating the logistical and financial support from several nations who all have different means, procedures and structures for financing their polar research.

Over time, for internal reasons, the NSF became increasingly reluctant to host the South Pole traverse. Moreover, the American project systematically received poor assessments from the project selection committee on which the NSF relies for funding. This resulted in a long process of application submission and rejection for the Americans that finally led to the withdrawal of the US teams in 2018 and the participation of the Australians but with no involvement on the ground. With the Italians having obtained funding through their National Antarctic Research Programme (PNRA) and the French from the National Research Agency (ANR), the BNP-Paribas Foundation and French Polar Institute Paul-Emile Victor (IPEV), two workshops in October 2018 and 2019 and numerous exchanges with the polar institutes laid the traverse's foundations: the route (round trip to the Mid Point Concordia-South Pole), research activities and traverse participation.

During the first meetings, three scientific

SCIENTIFIC OBJECTIVES

questions were identified.

The first was the mass balance in Antarctica, which directly affects sea level rise. Projections from the IPCC's Special Report on the Ocean and Cryosphere² indicate a sharp rise in sea levels of between 20 and over 100 cm by 2100. This wide range is largely due to uncertainty about the mass balance in Antarctica. However, if coasts continue to lose increasing amounts of ice, the question arises of what fate awaits the Antarctic Plateau. In a warmer climate, the atmosphere will contain more moisture and snowfall is expected to increase on the Antarctic continent, which, if not reversed, could slow down the rate of sea-level rise. A 1% loss of mass from the Antarctic continent represents a 70 cm rise in sea level. With 10% of the world's population living less than 10 m above sea level, the consequences would be catastrophic for societies and marine biodiversity. It is therefore essential to measure the evolution of snow accumulation rates over the central parts of

Antarctica and to place them in a historical context over the last few thousand years in order to obtain the best possible future projections.

The second question concerns the quality of the glaciological record contained in the ice. At deep drilling sites such as Vostok or Concordia, the accumulation of snow during the ice ages was about half of the levels in warm periods. In the hyper-arid zones of Antarctica, however, very specific surface structures can form. These include megadunes, where snow accumulation is highly variable (loss on the leeward and gain on the windward side of the dune) and can lead to biases in the recording of climatic and chemical signals. Going to study these areas of megadunes and other surfaces where snow accumulation has been impacted by ablation processes enables us to set foot on a terrain similar to what might have happened during an ice age at Vostok or Concordia and to see how the signals are recorded.

The final issue addressed by EAIIST concerns the representative nature of the measures currently being taken near research stations such as Concordia. The activity of a station running on fuel-based power inevitably generates local snow pollution, the consequences of which are sometimes difficult to assess: contamination of the snow, thermal structure of the snowpack, redistribution of the snow by wind, lack of zone marking for sampling areas, passage of non-listed vehicles, and so on. Conducting experiments in virgin ground makes it possible to assess the impact and biases that a station's activity can generate.

Finally, EAIIST is now YOPP (Year of Polar Prediction) endorsed. YOPP is an international initiative coordinated by the World Meteorological Organization to promote international cooperative research for the development of improved meteorological and environmental prediction services for the polar regions, on time scales ranging from hours to seasons. EAIIST therefore plans to make all of its meteorological data available to the community.



The project has brought together around twenty

THE CONSORTIUM

teams, with the participation of the Laboratory of Climate and Environmental Sciences (LSCE), European Centre for Research and Teaching in Environmental Geoscience (CEREGE), Strasbourg Institute for Earth Physics (IPGS) and Institute of Environmental Geosciences (IGE) for France, the National Institute of Geophysics and Volcanology (INGV), National Research Council of Italy (CNR), Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA), and the universities of Venice, Bologna and Florence for Italy, and the Australian Antarctic Division (AAD) for Australia. To these we must, of course, add the French Polar Institute Paul-Emile Victor (IPEV) and the National Antarctic Research Programme (PNRA) for the logistical aspects. The traverse participants will be selected from these teams.

megadunes

Surface undulation with an amplitude of a few tens of meters for a wavelength of a few km. Structure formed by the combined effect of wind, accumulation and slope of the surface.

glazed

Wind-hardened surface with very little surface relief, which does not allow snow to be deposited



THE CHOSEN ROUTE

Having adjusted for the fact that the Americans were no longer project participants, a new route was defined with the constraint of having to make the round trip in the same season since there was no longer any support available at the South Pole. Seeking to protect the project's initial objectives, it was finally decided to travel as far as the megadunes areas, around 640 km from Concordia. The distance of this round trip meant that it could be made in one season, but it also meant that it was possible to recover, by air or over land, some of the scientific equipment that the traverse had left on site to cover a full year's worth of recordings. On the basis of the scientific questions and satellite maps, five locations were defined (Table 1).

	POINT BARNOLA	AGOS	PALÉO	WIND	MEGA accumulation	MEGA érosion
Contact.	75°42'33"S 123°15'30"E	77°14'17"S 123°28'35"E	79°38'47"S 126°8'15"E	80°47'58"S 122°10'38"E	80°34'15"S 121°38'33"E	80°34'39"S 121°47'58"E
Distance Concordia / km	68	239	512	637	613	612
Relevance	Close to Concordia, no pollution	American geophysical station, uniform accumulation area	Uniform accumulation area	Glazed surface, probably ablated	Megadune accumulation area	Megadune erosion area

table 1 . Locations defined for extended 'science' stops.

SCIENTIFIC PROGRAMME

As mentioned above, the organisation of a scientific traverse in a hostile, isolated environment that is restrictive for both machines and people, involves significant costs that have to be optimized by maximising the possible scientific returns, while at the same time answering scientific questions. In accordance with this principle, the planned scientific activities were as follows:

SNOW PHYSICS

- SPECTRAL ALBEDO for energy budget
- SNOW STRUCTURE AND SURFACE ROUGHNESS for energy budget and comparison with satellite microwave measurements
- SNOW DENSITY for energy and accumulation budgets
- THERMAL GRADIENTS AND LIGHT PENETRATION INTO THE SNOWPACK for energy budget
- DEPLOYMENT OF BEACONS to measure accumulation

SNOW CHEMISTRY

- SNOW PITS for measuring surface glaciological records
- SURFACE SNOW for spatial variability of the records
- DRILLING for accumulation measurements and spatial and historical variability of the records

GEOPHYSICS

- SURFACE RADAR to determine snowpack layers and to spatially monitor accumulation changes
- SEISMIC STATIONS to make soundings of glacier movements and thickness
- GPS STATIONS to determine flow directions and speeds

ATMOSPHERIC PHYSICS

- TEMPERATURE, HUMIDITY, PRESSURE, WIND SPEED AND DIRECTION, SOLAR RADIATION, ACCUMULATION pour le bilan de masse et la météorologie

ATMOSPHERIC CHEMISTRY

- WATER VAPOUR ISOTOPES for air-snow transfer functions
- MASS AND SIZE DISTRIBUTIONS OF AEROSOLS for comparison with Concordia and for air mass transport
- AEROSOL COLLECTION for comparison with Concordia and air-snow transfer functions
- NITROGEN OXIDES for comparison with Concordia and air-snow transfer functions

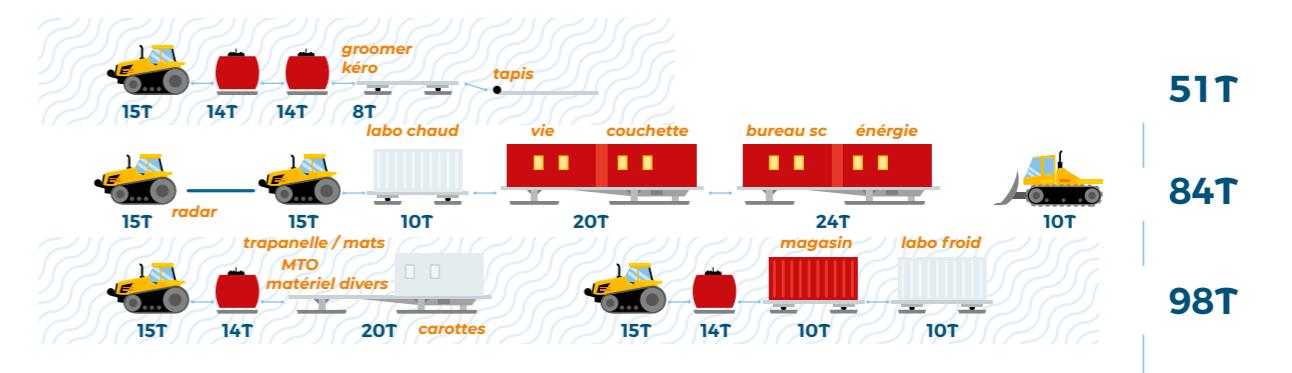
All these tasks are unevenly distributed depending on the site visited

ORGANISATION

On the strength of this scientific programme, different working meetings made it possible to establish a chronogram, the configuration of the traverse, allocation of tasks and staff rotation. A season on the Antarctic plateau corresponds to only around sixty days of scientific activities in summer. Taking into account the necessary preparations, fifty traverse days were finally available to carry out EAIST. On top of these fifty days on the Antarctic plateau, 2 x 10 days of driving were required to bring the vehicles from the coast to Concordia and back down again. In order to allow all the scientific experiments to be carried out, there was a staff rotation system for the megadunes area which meant that 15 people could participate, even though the traverse has only 10 beds. The convoy set-up was designed by the Polar Institute to accommodate staff, ensure a high level of security and be capable of transporting all the equipment.



SHOWS ITS CONFIGURATION



DETAIL OF THE EAIST TRAVERSE CONFIGURATION

There are five Challenger C65 tractors, sleds, fuel tanks, a snow groomer, life caravan (kitchen, office, beds, communication), energy caravan (mechanical workshop, bathroom facilities, shower, generator, food supply) and two CLIMCOR mobile laboratories (one hot, one cold). Because, in previous years, the transport of equipment and staff had come up against difficulties caused by sea ice-related hazards, the shipment of heavy equipment

was brought forward to year n - 1. This turned out to be a critical choice. Beyond gaining flexibility and being able to work independently of the sea ice conditions, the damage to the Astrolabe vessel at the beginning of the 2019 season would have dealt a fatal blow to the traverse project now considering the COVID-19-related issues that also arose.

THE FIVE CHALLENGER TRACTORS, THE GROOMER AND THE DIFFERENT TOWED LOADS ARE SHOWN. THE CONVOY CONSISTS OF THE HOT LAB AND THE LIFE AND ENERGY CARAVAN. THIS ASSEMBLY MADE IT POSSIBLE TO KEEP THE LABORATORY AND THE LIVING AREAS WARM DURING THE DRIVING PHASES, WITH THE ENERGY CARAVAN'S GENERATOR KEPT RUNNING DURING THE TRIPS.

THE TRAVERSE

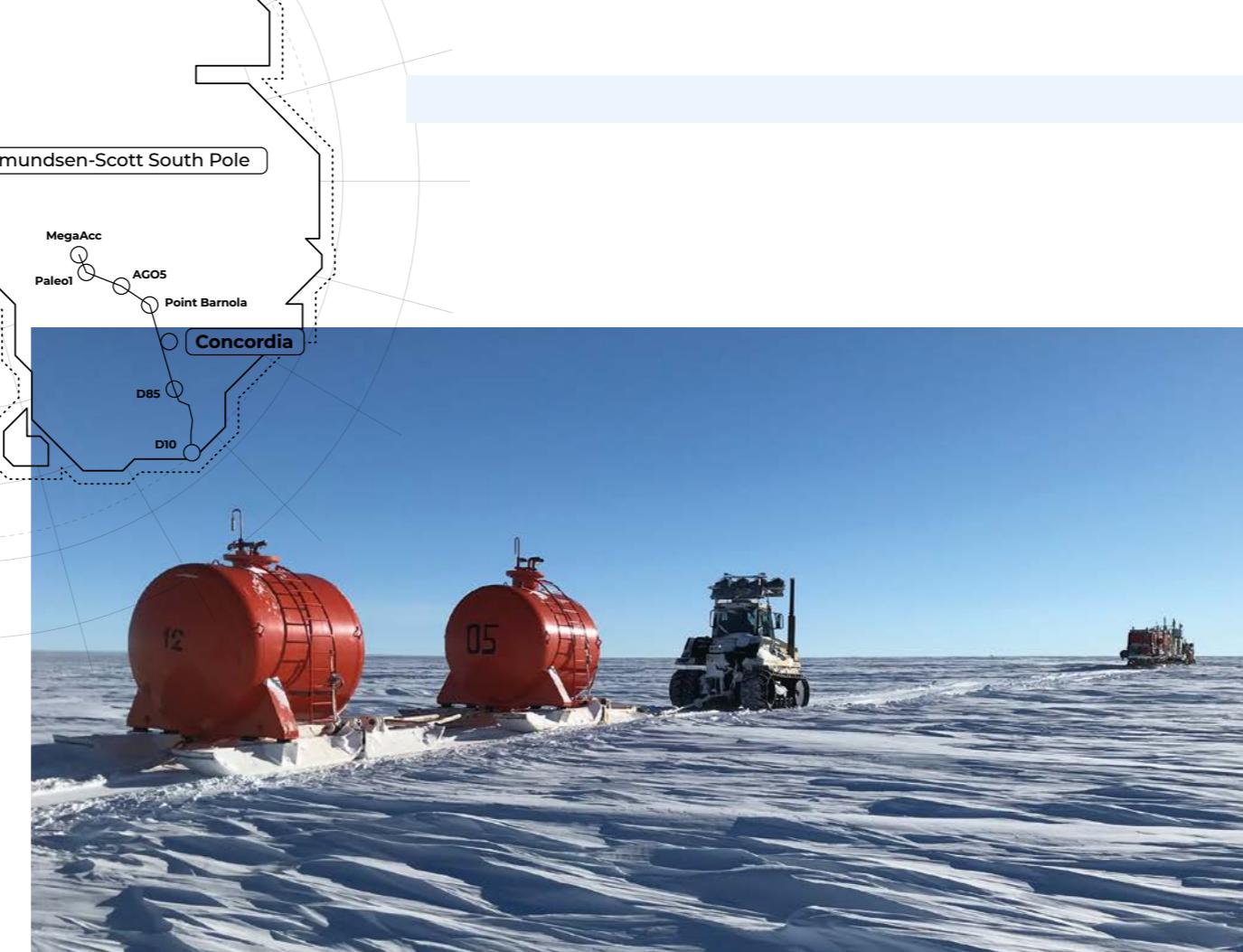
THE TEAM AND HUMAN FACTORS

Selecting a team for an isolated traverse in quasi autonomy is not a task to be taken lightly. While it is always difficult to predict the dynamics of a group that will be living in very close quarters, it is worth attending to this aspect before setting out. The initial requirement was to have on board a competent and experienced technical team consisting of a traverse leader, two mechanics and a doctor. That left six places for scientists, who needed to be experienced and familiar with the terrain and its difficult conditions, adaptable and able to multi-task. There also had to be both French and Italian contingents in the traverse. I also wanted as many women as possible to be involved so as to have varied and complementary viewpoints on subjects that may arise during the 70 days of voluntary confinement.

The technical team was established by the French Polar Institute. It was composed of Anthony Vendé, traverse leader, Alexandre Leluc and Quentin Celle, mechanics, and Nicolas Rombauts, part-time emergency physician and designated cook.

As for the scientists, the various meetings had made it possible to compose a complementary and experienced team consisting of Joël Savarino (IGE), scientific coordinator and chemist, Nicolas Caillon (IGE), chemical engineer, Pete Akers (IGE), post-doctoral chemical researcher, Mathieu Casado (AWI), post-doctoral chemical researcher, Andrea Spolaor (U. Venice), chemical researcher, Graziano Larocca (INGV), geophysics engineer, Emmanuel Le Meur (IGE), geophysics senior lecturer, Fanny Larue (IGE), post-doctoral researcher and physicist (the only woman, much to my regret), Vincent Favier (IGE), observatory physicist, Laurent Arnaud (IGE), geophysics engineer, Ghislain Picard (IGE), professor in geophysics and Philippe Possenti (IGE), design engineer, driller.

Everybody had years of polar experience in every configuration possible (working in research stations, isolated camps, traverses, alpine environments) with scientific specialities that were purely polar. As already mentioned, although it is difficult to predict group dynamics, I feel that everybody got on extremely well. Each person added their own identity and complementary perspective to the group. There was hardly any tension between us as everybody made an effort to be as accommodating as possible in a spirit of warmth, conviviality and kindness. As coordinator, I received almost no complaints, and the very few I did receive were incidental. Encounters with the logistics traverse supplying the Concordia research station on the shared road sections were some of the high points of the traverse. This is



not really a place where you think you'll bump into somebody along the road. Some of the most memorable moments of the traverse were getting together in such a cordial and friendly atmosphere, in the middle of nowhere, having a drink, enjoying a meal with the 'science boids' and 'techies', and staff changeovers at the megadunes.



- 1 · Nicolas Rombauts, notre doc
- 2 · Graziano Larocca, dépose des sismomètres
- 3 · Anthony Vendé, chef de raid
- 4 · Emmanuel Le Meur, radar de surface
- 5 · Ghislain Picard, propriétés physique et optique de la neige
- 6 · Quentin Celle, mécanicien
- 7 · Andrea Spolaor, chimiste de la neige
- 8 · Philippe Possenti, forger
- 9 · Vincent Favier, données météo et accumulation de neige
- 10 · Laurent Arnaud, ingénieur instrumentaliste
- 11 · Alexandre Leluc, mécanicien
- 12 · Nicolas Caillon, ingénieur chimiste
- 13 · Pete Akers, géochimiste
- 14 · Joël Savarino, coordinateur scientifique et chimiste atmosphère et neige
- 15 · Fanny Larue, propriétés physique et optique de la neige
- 16 · Mathieu Casado, climat et isotopes de l'eau

THE JOURNEY

The EAIIST traverse took place from 23 November 2019 to 5 February 2020. The journey, based on the analysis of satellite maps, was made up of 34 days of driving (including time to get vehicles to the departure point) at an average speed of 12 km/h, 19 days of technical stops at Cap Prud'homme and Concordia and 26 days of 'scientific' stops.

Figure 2 shows the GPS track of the route followed by the EAIIST traverse with the evening stops and the visited sites (Table 1). We were able to follow the planned route exactly. Staff changeovers were seamless and took place on the agreed days. The traverse went almost without a hitch. The only real technical problems encountered were the malfunctioning of a hydraulic power station, which had no impact on the traverse, and an engine failure on a Challenger that required the loads to be redistributed. Fortunately, this happened on the return journey and only 100 km from Concordia. If it had happened earlier it would have caused serious problems. Some other incidental issues that were taken care of without delaying the traverse's progress were a broken tiller, the replacement of a sled runner axle, breakage of a snow groomer's window, as well as other mechanical problems. The positive atmosphere that prevailed throughout the traverse was also the result of this excellent progress. Returning to the coast with no pressure and ahead of schedule, we made a detour to a site visited by the ASUMA traverse in 2017 to repair a broken weather station.

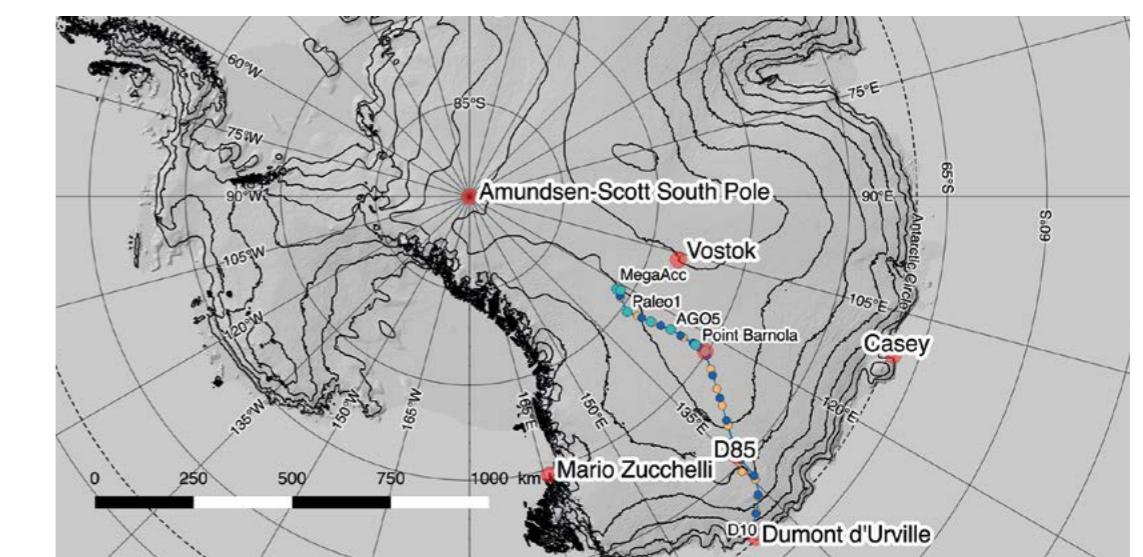
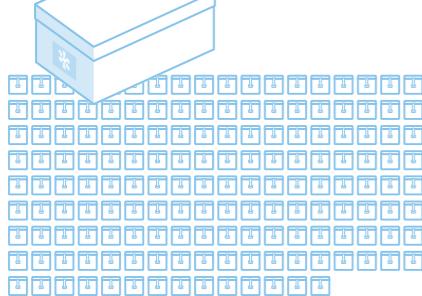


Figure 2. **EAIIST traverse route** (approx. 3700 km in 70 days with the various long science stops and short night stops. Except at the exit of the Concordia station, the vehicles found load-bearing terrain along the entire route which meant that the only time they got stuck was the first day of the traverse when leaving Concordia).

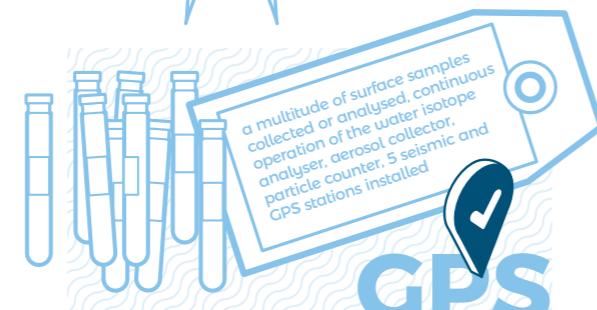
THE MISSION

3657 km of traverse

158 ISOTHERMAL BOXES BROUGHT BACK



5 snow pits



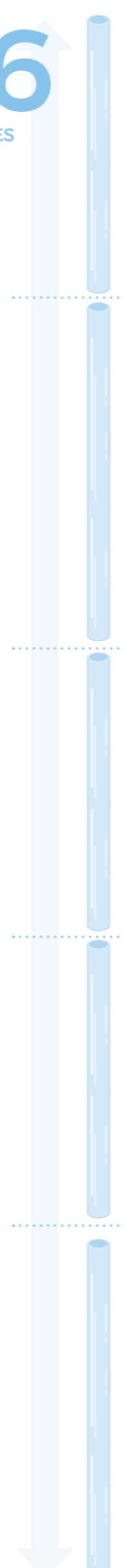
GPS

All of the cores could be taken. No major problems threatened the smooth execution of the scientific programmes. Once again, like the logistics, the science had only minor problems to deal with that had no consequences for the experiments. For example, a malfunction of the particle counter caused by very low temperatures led to no data being obtained during the Prud'homme - Dôme C pre-routing. Once transferred inside the CLIMCOR hot laboratory, however, the counter worked without a hitch. The loading of the NO_x monitor on the Prud'homme - Dôme C portion ensured a minimum of data for this task. Unfortunately, an on-site breakdown of the UV lamp at Concordia prevented us from taking it on the EAIIST traverse as the replacement UV lamp did not arrive until the end of the summer season.

Given the difficulty of operating the FELICS core drill in the CLIMCOR cold laboratory by staff without the proper experience, it was decided to take on board a master driller (Philippe Possenti) at the start of the expedition. This turned out to be a decisive choice for the success of the drilling programme. The rapid execution of some of the drillings saved precious time. Each project manager's experience was deployed in the field and they will all now have something to work on (Table 2). We can be confident that the data collection will lead to first-class publications. The analysis of this body of experience will take time and at this stage, it has not yet been possible to present concrete results that answer the scientific questions posed at the start of the project.

By way of illustration, Figure 3 shows the first meteorological data transmitted by the megadune station and analysed by Laurent Arnaud. In view of the results of the data and samples acquired, I consider that all the scientific objectives set for the traverse have been achieved and even, in some cases, exceeded.

906 METRES OF CORES



	Ancillary activities	Continuous measurements	Fixed and ad hoc devices	Drilling	Pits	Surface	Problems (Pb) Repairs (Rep)
PREPARATION							
PRUD-DC	Loading of material ASUMA beacon data collection	Putting the isotope monitor and aerosol collector into operation Water isotope • Aerosol collection		At each stop • 1 core 1.3m	At each stop • 1 snow sample at 1m	At each stop • 1 snow sample isotope • 1 snow sample chemistry	Pb Particle counter
DC	Loading of material Core drill test Staff changeovers	Water isotope • Aerosol collection • Particle counter				At each stop • 1 snow sample isotope	Pb Particle counter
DC-AGOS		Water isotope • Aerosol collection • Particle counter • Surface radar • Roughness measurement	Point Barnola • Seismic station FR • GPS station	Every 20kms • 2 cores 1.5m • 1 snow sample	At each stop • 1 snow sample at 1m	At each stop • 1 snow sample isotope • 1 snow sample chemistry • Spectral Albedo • Grain size	Pb FELICS core drill Counter repair
AGOS		Installation of core drills • Aircraft runway	Water isotope • Aerosol collection • Particle counter • Surface radar • Roughness measurement • Spectral Albedo	2x48m • 2x18m • 2x8m • Density/size 8m • Temperature 10m • Conductivity measurement 8m		2m chemistry • 1m isotope N	1 snow sample isotope 1 snow sample chemistry • Spectral Albedo • Grain size
AGOS-PALEO		Water isotope • Aerosol collection • Particle counter • Surface radar • Roughness measurement	Mid Point • Seismic station FR • GPS station • Albedo spectral measurement • SOLAB Transect	Tous les 20kms • 2 carottes 1.5m • 1 éch neige	At each stop • 1 snow sample at 1m	At each stop • 1 snow sample isotope • 1 snow sample chemistry • Spectral Albedo • Grain size • Photogravimetry	
PALEO		Installation of core drills • Aircraft runway	Water isotope • Aerosol collection • Particle counter • Surface radar • Roughness measurement • Spectral Albedo	2x48m • 1x18m • 2x8m • Density/size 8m • Temperature 10m • Conductivity measurement 8m		2m chemistry • 1m isotope N	1 snow sample isotope 1 snow sample chemistry • Spectral Albedo • Grain size • Multiphoto
PALEO-WIND		Water isotope • Aerosol collection • Particle counter • Surface radar • Roughness measurement	PALEO-WIND	Every 20kms • 2 cores 1m • 1 snow sample	At each stop • 1 snow sample at 1m	At each stop • 1 snow sample isotope • 1 snow sample chemistry • Spectral Albedo • Grain size	
WIND	Italian radar test • Installation of core drills • Aircraft runway	Water isotope • Aerosol collection • Particle counter • Surface radar transect • Roughness measurement • Spectral Albedo	Seismic station IT • GPS station • Sastrugi orientation	2x50m • 2x20m • 2x8m • Density/size 8m • Temperature 10m • Conductivity measurement 8m		2m chemistry • 1m isotope N	Pb: ForPossum corer
MÉGAACC	Staff changeovers • Installation of core drills • Aircraft runway	Water isotope • Aerosol collection • Particle counter • Surface radar transect • Roughness measurement • Spectral Albedo	Seismic station FR • GPS station • CMP borehole radar	1x162m • 1x50m • 1x20m • 2x8m • Density/size 8m • Temperature 10m • Cutting IC 8m		2m chemistry • 1m isotope N	Conductivity abandoned and replaced by IC cut-out
MégaEro	Staff changeovers • Installation of core drills	Water isotope • Aerosol collection • Particle counter • Surface radar transect • Roughness measurement • Spectral Albedo	Seismic station FR • GPS station • CMP borehole radar • Weather station	1x50m • 1x20m • 2x8m • Density/size 8m • Temperature 10m • Cutting IC 8m		2m chemistry • 1m isotope N	Rep: ForPossum drum
MégaEro-PALEO		Water isotope • Aerosol collection • Particle counter	GPS Station recovery		At each stop • 1 snow sample at 1m	At each stop • 1 snow sample isotope • 1 snow sample chemistry	

table 2 . all the experiments conducted at different points during the EAIIST traverse.

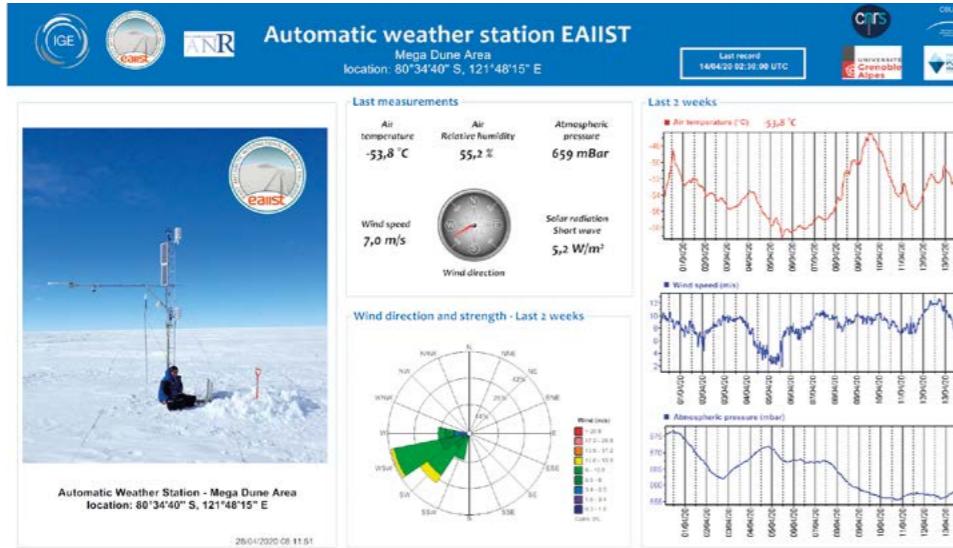


Figure 3. Readings from the automatic weather station installed in the megadunes area, located 610 km from Concordia. The stations are operated by solar panels and batteries. The data are sent by the Iridium satellite constellation on a daily basis.

CONCLUSIONS AND PROSPECTS

Taking stock of such an operation, a great deal of scientific work remains to be done, but it is evident that the amount of effort that was needed on all levels is astounding. Nearly 8 years of preparation were necessary, a period marked by countless meetings, failures, exchanges, and also crises (an emotional experience). Yet, despite the meticulous preparation, there is also a certain amount of luck involved. Had the engine breakdown occurred in the middle of the scientific programme, it would have been a completely different story. And what about the emergence of a pandemic, the type the world has not witnessed since the Spanish flu? The need to prepare this type of complex project well in advance goes without saying because of the type of terrain, how the scientific programme is structured, and the safety of all staff involved. However, luck must also be on your side. What this experience has shown is that long and meticulous preparation work carried out well beforehand and by seasoned and experienced staff is a sine qua non for the success of such an undertaking. Yet this is not enough, as even though it reduces the risks, it cannot eliminate them. I am also aware of the sheer effort and amount of work required to prepare for and to implement such a traverse. The interdependence of people with different profiles is probably what best embodies this type of project.

Finally, on a more forward-looking aspect, scientific tractor traverses are still fantastic exploration tools, but are also heavy infrastructures that are not very agile, and lack flexibility and adaptability. While this approach is perfectly suited to traverses where scientific operations require a large payload, their 'heaviness' can also become an impediment. The Institute is currently working with scientists to find ways of providing a lighter infrastructure capable of covering large areas in a short space of time while guaranteeing safety and autonomy. Having such an infrastructure would make a significant contribution to the study of the strong gradients of altitude, accumulation, temperature, wind, humidity and flow observed along the Dumont d'Urville - Concordia axis.

Finally, it was a shame that there was no film crew on the traverse as initially planned to make a EAIIST documentary, as this will now have to be done with amateur footage and with a different form of narration.

Nevertheless, with luck on our side (favourable weather, good snow, few worries), EAIIST remains a great success both scientifically and logistically and is fully in keeping with the IAGP approach.



ACKNOWLEDGEMENTS

Once again, I would like to offer my sincere thanks to all of the teams who enabled this traverse to be carried out, regardless of whether they participated in the field or not. I thank our financial supporters, the French National Research Agency (agreement ANR-16-CE01-0011-01) and the BNP-Paribas Foundation (sponsorship agreement 2017-6639), without whom this traverse could not have taken place. I also thank all the French Polar Institute teams and the PNRA, management, administration, communications, logistics and technical services that make polar research possible and who have worked countless hours to achieve the results. I would also like to express my gratitude again to our supervisory authorities, CNRS and Grenoble Alpes University for their support in kind. My final words go to the entire EAIIST team, from the overwinterers to the technical and research teams. This experience was enriching and a remarkable achievement made possible through great teamwork.





French Polar Institute



MISSIONS 48

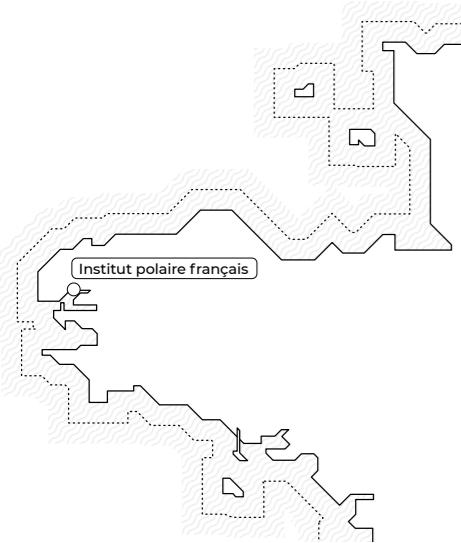
DATA 50





mission

The French Polar Institute is a public organization responsible for bringing to fruition French research operations in the polar regions of the Globe.



FRENCH POLAR INSTITUTE

participates in international consultations on scientific, logistical and environmental considerations and often represents France in that capacity.

Access and living conditions in these zones of the world are difficult. The French Polar Institute deploys substantial resources and specially adapted, technologically advanced systems to research sites. The Institute also employs people with the special knowledge and skills required for top quality scientific research in extremely harsh polar conditions.

RECRUITMENT of the personnel needed for upkeep and maintenance of research stations and for ensuring the continuity of scientific studies over the Southern winter

TRANSPORT and transfer of freight and personnel between metropolitan France and the various destinations

ENSURING sustained maintenance of research stations

DEVELOPMENT of new technological solutions for logistics and polar infrastructure

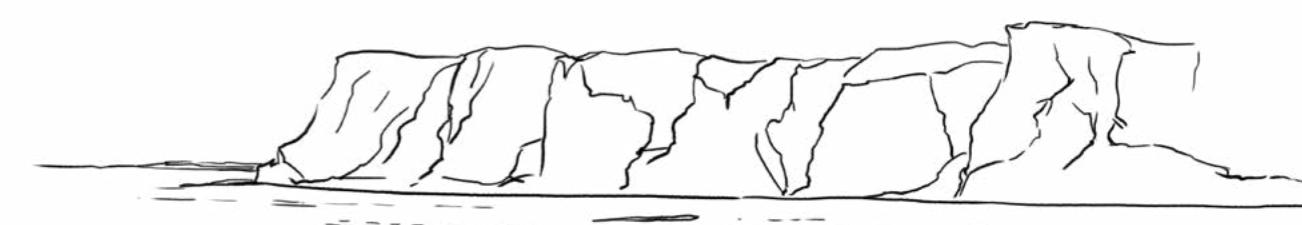
ORGANIZATION and planning of technical programmes and scientific projects

DISSEMINATION of scientific knowledge concerning the polar environments

SELECTION of scientific projects through assessment by the French Polar Institute's Scientific Committee, finance for their field-operations and for expedition organization

TRAINING safety and security of all concerned

SUPPLY of equipment well adapted for life in polar environments





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- French representative at the Forum of Arctic Research Operators (FARO) and executive member since march 2020
- French representative on the International Arctic Science Committee (IASC)
- Member of the Steering Committee of TGIR Concordia
- Participant in the European PolarNet project
- Participant in the European Beyond

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- Annual EGU Geosciences Union "Official launch of Beyond Epica-Oldest Ice Core Project" à Vienne • APRIL 2019
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- Ny-Alesund Science Managers Committee (NySMAC) à Arkhangelsk • MAY 2019
- International Arctic Science Committee Council à Arkhangelsk • MAY 2019
- Forum of Arctic Research Operators (FARO) Meeting à Arkhangelsk • MAY 2019
- Comité pour la Protection de l'Environnement et Réunion Consultative du Traité sur l'Antarctique à Prague • JULY 2019
- Concordia Science Committee à Rome • JULY 2019
- Steering Committee Concordia à Rome • JULY 2019
- COMNAP Annual General Meetings and Symposium à Plovdiv • JULY 2019
- Pre-departure meeting Concordia à Trémisini • SEPTEMBER-OCTOBER 2019
- Workshop Franco-Russe Sibérie à Paris • OCTOBER 2019
- European Polar Board - Plenary Meeting à Brest • OCTOBER 2019
- Visite officielle de la Ministre de la Recherche en Antarctique • NOVEMBER 2019
- Rencontre France-Canada à Québec • DECEMBER 2019
- Beyond EPICA Steering Committee, en videoconference • DECEMBER 2019
- Réunion avec l'Alfred Wegener Institute (AWI) à Hambourg • FEBRUARY 2020
- Beyond EPICA SSC, en videoconference • MARCH 2020
- Steering Committee Ice Memory, en videoconference • MARCH 2020
- European Polar Board - Plenary Meeting, en videoconference • MARCH 2020
- International Arctic Science Committee Council, en videoconference • MARCH 2020
- Forum of Arctic Research Operators (FARO) Meeting, en videoconference • MARCH 2020
- Ny-Alesund Science Managers Committee (NySMAC), en videoconference • MARCH 2020

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- Forum of research operators in the Arctic (FARO) in Arkhangelsk • MAY 2019
- General Assembly and Symposium of the Council of Managers of National Antarctic Programmes COMNAP in Plovdiv • JULY 2019
- Committee of Scientific Operators in Ny-Alesund (NySMAC) in Oslo NOVEMBER 2019
- Meeting with the Alfred Wegener Institute (AWI) in Hamburg • FEBRUARY 2020
- Committee of Scientific Operators in Ny-Alesund (NySMAC) videoconference MARCH 2020

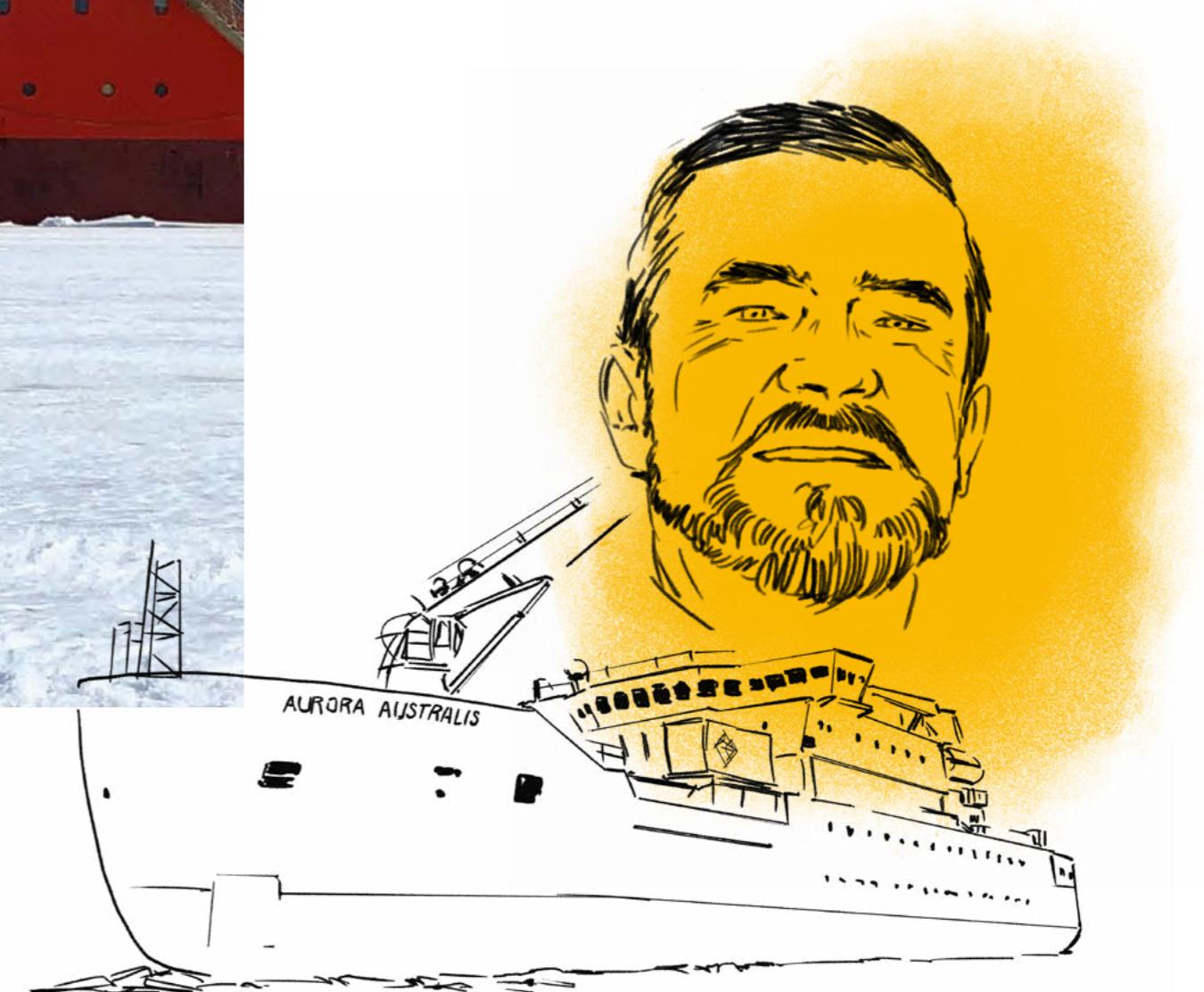


Annual report 2019-2020

Partner



AAD
**AUSTRALIAN
ANTARCTIC DIVISION** 54





Australian Antarctic Division



Kim ELLIS,
Australian Antarctic Division

Australia and France have long enjoyed a warm relationship in Antarctica and the sub-Antarctic. These close ties were evident this summer when the French Antarctic Program called for assistance, after its icebreaker became unserviceable, due to a damaged propeller. The Australian Antarctic Division (AAD) was able to resupply the French Antarctic station, Dumont D'Urville, and transport a new team of wintering expeditioners south.

While Australia's icebreaker, Aurora Australis, delivered expeditioners, cargo and 250,000 litres of fuel to the station, the AAD also flew 14 French passengers to the joint French/Italian station, Concordia.



Such assistance is part of the spirit of cooperation that exists in Antarctica, but it also reflects the long and close relationship between Australia and France.

As original signatories to the Antarctic Treaty, we have a strong, shared history, including as lead proponents of the Protocol on Environmental Protection to the Antarctic Treaty (Environmental Protocol), which indefinitely bans mining in Antarctica. Our two countries are also geographical neighbours in Antarctica, and we have adjacent Exclusive Economic Zones (EEZs) on the sub-Antarctic Kerguelen Plateau.

As a result of our scientific collaborations on marine ecosystem and fisheries research on the Kerguelen Plateau, we have adopted complementary approaches to toothfish stock assessments in our EEZs. This approach has been welcomed by the Commission for the Conservation of Antarctic Marine Living Resources – the key body responsible for the conservation of marine ecosystems and fisheries management in the Southern Ocean.

The AAD and the French Polar Institute Paul-Emile Victor (IPEV) also work closely together under various agreements that demonstrate our shared commitment to good governance, environmental protection and scientific excellence.

THESE INCLUDE:

- **The Vision Statement on the Australia-France Relationship** signed in May 2018 by Prime Minister Malcolm Turnbull and President Emmanuel Macron. The statement includes a section on Antarctic and Southern Ocean cooperation acknowledging the leaders' commitment to work together to advance shared policy, science and logistic objectives.

- **A Treaty between the Government of Australia and the Government of the French Republic, on Cooperation in the Maritime Areas adjacent to the French Southern and Antarctic Territories, Heard Island and the McDonald Islands**, which entered into force on 1 January 2005. Among other things, the Treaty encourages scientific research on marine living resources.

- **The 2012 Memorandum of Agreement on Antarctic Cooperation between the AAD and the IPEV** – a non-binding agreement on cooperation in Antarctic science, coordination, data-sharing and efficient sharing of logistics.

- **Quid-pro-quo' arrangements between the AAD and IPEV**, sharing Antarctic logistical capabilities on an annual basis. For example, IPEV has previously provided Australia with shipping support to Macquarie Island, while in 2019-20 the AAD assisted France following damage to the L'Astrolabe.

In 2019-20 both nations progressed projects in search of an ice core with a million-year climate archive – France by finalising site selection and setting up a drill camp near Concordia in conjunction with European consortium colleagues; Australia by working on our drill development, general planning and preparation of traverse equipment. These two ice coring projects, one led by Australia and the other by the European consortium, will be highly collaborative and part of the cooperation within the International Partnerships in Ice Core Sciences.

We look forward to continued opportunities for collaboration as we strive towards our shared vision of excellence and innovation in Antarctic and sub-Antarctic science, governance and environmental protection.



Scientific programmes supported



SCIENTIFIC PROGRAMMES SUPPORTED
IN ARCTIC

58

SCIENTIFIC PROGRAMMES SUPPORTED
IN ANTARCTIC AND
SUBANTARCTIC ISLANDS

79





330 ORNITHO- ENDOCRINO

PHYSIOLOGICAL AND FITNESS CONSEQUENCES
OF EMERGING CONTAMINANTS EXPOSURE IN
ARCTIC SEABIRDS

In the frame work of the ORNITHO-ENDOCRINO research program, we will study the physiological and fitness effects of poly- and perfluorinated alkyl substances (PFASs) exposure in Svalbard Black-legged kittiwakes. PFASs are surface-active agents used in a multitude of manufactured and consumer products and are nowadays the most abundant contaminants in many Arctic seabirds, but their effects remain poorly known. We will:

Investigate in deep the influence of PFASs on key endocrine mechanisms underlying reproductive decisions and parental effort (corticosterone, LH, prolactin)

Explore via the study of telomeres dynamics the impact of PFASs contamination on the rate of ageing of individuals

Assess the consequences of PFASs exposure on fitness traits like reproductive success and survival.



- AWIPEV - Ny Alesund ARCTIC
- Chastel Olivier

333 PARASITO- ARCTIQUE

HOST-PARASITE INTERACTIONS IN SPACE:
DISPERSEL AND LOCAL INTERACTIONS IN
ARCTIC SEABIRDS.



The aim of this research program is to examine the response of animal populations to environmental variability at different spatial scales. The study system is a host-parasite system at three levels, involving arctic seabirds as hosts, the tick *Ixodes uriae* as their ectoparasite and microparasites such as Lyme disease agent *Borrelia burgdorferi* and arboviruses. The role of the variability in host phenotypic responses (immunology and behaviour) and of the coevolution between the hosts and the vector tick for the ecology and evolution of such interactions at different scales will be studied. In addition to laboratory analyses, the approach combines field experiment to the analyses of data recorded in a spatialised context.

- Norvège ARCTIC
- Boulinier Thierry

388 ADACLIM

RESPONSES OF ARCTIC MARINE BIRDS TO ENVIRONMENTAL CONSTRAINTS IN THE CONTEXT OF CLIMATE CHANGE

It is essential to reach a better understanding of ecological processes in the Arctic, as this ecoregion is hit severely by the consequences of global change. In this context, we study the ecophysiology of little auks (*Alle alle*), which are the most abundant seabirds of the Arctic, and acknowledged ecological indicators of changing marine ecosystems in this polar region. Via a long-term study of little auks breeding in East Greenland (Liverpool Land), in place since 2005, but also through specific experimental and modelling approaches, as well as through a panarctic network of collaborations, we test the following hypotheses:

- Arctic climate change is impacting the trophic status, the foraging ecology, the reproductive output, the body condition and the multi-annual survival of adult little auks during the breeding season.
- Ongoing climate change impacts the migratory ecophysiology of little auks in the North Atlantic.
- Flight and diving energetics condition the functional ecology of little auks - among the world's smallest diving marine homeotherms.
- Climate change is generating thermal stress for arctic seabirds, with impacts on their reproductive performances.
- Environmental contamination impacts little auk ecophysiology, behaviour and breeding success, with long-term population effects.
- The pan-arctic seabird community functions as a natural monitoring network for both legacy and emerging contaminants. All of our work participates in the Circumpolar Biodiversity Monitoring Programme (CBMP) of the working group Conservation of Arctic Flora and Fauna (CAFF) of the Arctic Council, and therefore corresponds to the expectations of arctic peoples in terms of environmental research.

Groenland ARCTIC
 Gremillet David



1036 INTERACTIONS

DIRECT AND INDIRECT IMPACTS OF DIFFERENT PARASITE-PREDATOR-PREY INTERACTIONS ON THE CYCLIC DYNAMICS OF AN ARCTIC TERRESTRIAL VERTEBRATE COMMUNITY SUBJECT TO CLIMATE CHANGE

The Arctic region is warming more rapidly than any other region on Earth, and predict the response of biodiversity to climate change (CC) has become an extremely active field of research. Most studies of the impacts of CC on biodiversity have so far focused on individual responses, mainly on phenology, physiology or range shifts. However, it is increasingly apparent that biotic interactions drive key ecological and evolutionary processes and mediate ecosystem responses to CC. Thus, predicting the effects of CC is dependent upon identifying the interactions between species that are most vulnerable to changing climate and are key determinants of the structure and function of a community. Predator-prey interactions (PPI) play a determinant role in structuring Arctic terrestrial vertebrate communities, and understanding how the strength of these interactions varies under the constraints of CC is crucial to assess ongoing changes in Arctic biodiversity.

If PPI is primarily seen as the direct trophic (lethal) interactions between prey and predator species, at a community level it can also take many different forms. Thus, PPI can be non-trophic/non-lethal when predators induce antipredator responses (risk effects) in preys, hence not necessarily impacting their current abundance but rather their long-term survival and/or their breeding performances. This project is the continuation of our "INTERACTIONS-1036" program funded by the French Polar Institute-IPEV between 2011 and 2014 and extended during 2015-2018. In our previous programmes, we have deepened our understandings of the direct and indirect interactions between lemmings, shorebirds and their shared predators. The new INTERACTIONS program (2019-2022) will now aim at capitalizing on this expertise in order to broaden the picture to far more complex inter-specific interactions, and involving two aims:

Observations at larger time scale on the previously studied site in order to better appreciate the effect of yearly fluctuation;

Extension to the study of individual responses of predators and prey to the intensity of their interactions.

The originality of our new program consists in the mutual study of the behavioural responses of the prey and the predators to the variations of intensity of their interactions, and the consequences for the dynamics and distribution of the different populations.

Better understanding of the evolution of the predator-prey interactions in Arctic terrestrial ecosystems could have strong implications in our ability to understand the effects of CC on biodiversity and evolution.

Groenland RUSSIE
 Bollache Loic



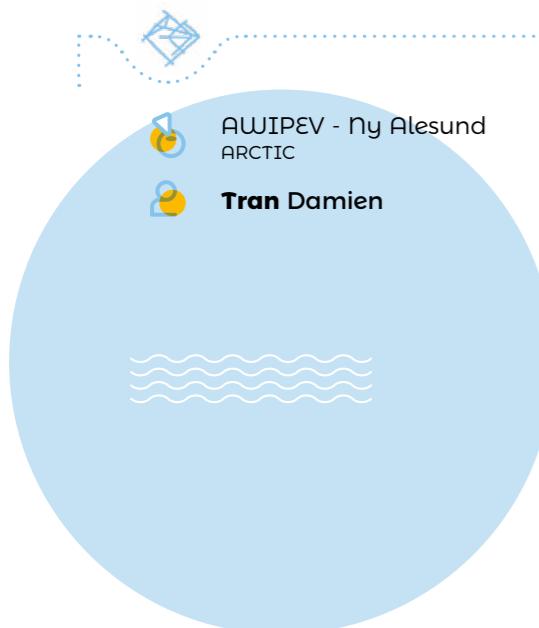
1166 ARTICLOCK

STUDY OF THE CIRCADIAN AND CIRCAANNUAL CLOCKS OF THE SCALLOP CHLAMYX ISLANDICA AND THE MUSSEL MYTILUS EDULIS LIVING IN THE HIGH ARCTIC.

This project is following a previous IPEV project in 2017 (project 1166) and it is a part of the ANR project WAQMOS (2015-2020). The aims is to study, through a chronobiological approach, the clockwork of the Arctic scallop Chlamys islandica and as well the mussel Mytilus edulis, especially during the polar night. The scientific context of this project, supported by recent studies, is that polar night could be associated to a time of high biological activity in marine organisms, although the prevailing paradigm suggests the opposite situation with the presence of biological quiescence during polar night. We have already shown that the circadian rhythm of valve behavior is maintained even through the polar night. In the present project, we propose to study:

- Endogenous mechanisms underlying the circadian rhythm;
- Their synchronization by light intensity variations;
- The circannual rhythm.

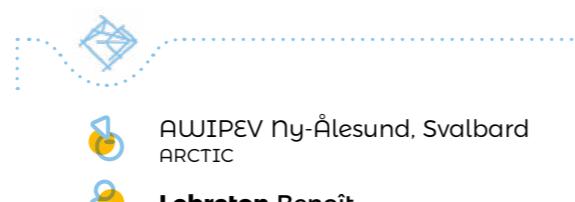
The molecular clockwork will be investigate in relationship with the valve behavior and the growth of bivalves. Finally, this study will be put into perspective to exacerbated global warming at the poles, which modify the life cycles between the bivalves and their food availability such as the phytoplankton.



1190 MAD FOOD 2

FATE OF MACROALGAE DETRITUS AS FOOD SOURCES IN POLAR COASTAL ECOSYSTEMS. PHASE 2.

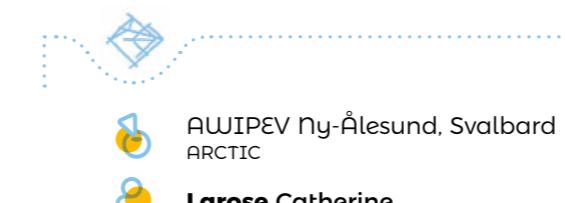
The west coast of Spitsbergen is one of the most impacted area in the world due to global warming, as Atlantic, Arctic and glacial waters converge and mix there. As a result, the Kongsfjorden is a very relevant ecosystem to better assess and predict what will be the fate of polar coastal ecosystems in the near future. A high production of macroalgae (i.e. kelps) occurs in such ecosystems but most of this production is not used as fresh by consumers. This organic matter may therefore be exported to other habitats like subtidal mudflats, where it can be trapped into the sediment. Aim of this project is to determine to which extent subtidal mudflats can act as storage areas for detrital matter of macroalgae origin and what is the fate of this organic matter in these habitats at two seasons: Summer, when primary production (i.e. macroalgae, phytoplankton) is high, and winter, when primary production is very low, suggesting that consumers have to rely on detrital food sources. In this aim, we will determine and compare the community structure of the benthic fauna at these two seasons and determine the role of macroalgae detrital matter in the functioning of subtidal mudflats using trophic markers (i.e. stable isotopes, fatty acids). Our results will thus provide information about the connectivity between two major habitats of polar coastal ecosystems: kelp belts and subtidal mudflats.



1192 MICROLIFE 2

MICROORGANISMS LIVING IN THE ARCTIC

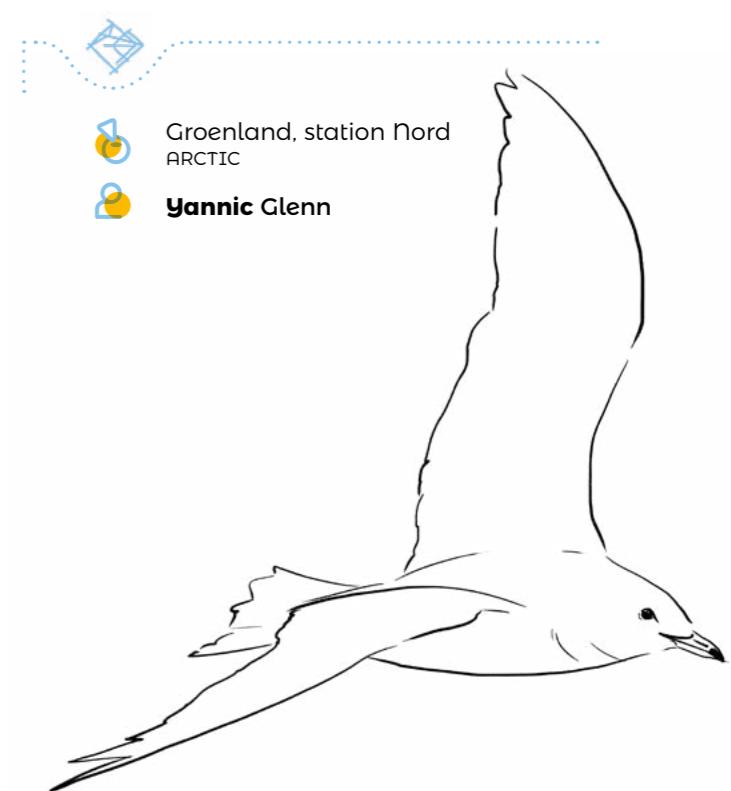
The Arctic is an area of growing strategic importance for European policy. As a consequence, there is an increasing need to estimate the impact that environmental change will have on the Arctic and our planet. Among the most critical, yet under-studied components of the Arctic cyrosphere is seasonal snow. Next to the ocean, snow is the second largest interface between the atmosphere and the Earth's surface during winter. Since snow on the land surface is thermodynamically unstable, it is in constant evolution due to metamorphism, whose rate is a function of temperature and the temperature gradient in the snow pack. As a result, snow, especially seasonal snow, is very sensitive to climate conditions and undergoes continuous modification in a changing environment. Despite the crucial role of snow for climatic, hydrological and biological processes, there are relatively few regular measurements of even the most basic snow parameters (e.g. snow thickness, snow density, temperature, snow hardness, the presence of ice layers) from the Arctic region in general and from Svalbard in particular. Even less is known about the biodiversity of the microbial communities inhabiting the snowpack and their biogeochemical processes in comparison with the rest of the terrestrial biosphere. In order determine the impact of climate change on terrestrial ecosystems, longer time series are needed that integrate different types of data (physical, chemical and biological). Many samples need to be collected, including precipitation sampling. The seasonal variability of snow also needs to be assessed in term of properties and length of the period between senescence and freezing (before/after the snow comes). With MicroLife2, we are proposing to provide such time series data through yearly sampling of snow in collaboration with NPI and onsite research staff. Using these samples, we will address a series of questions related to microbial ecology as well as adaptation to change. The knowledge of the relative importance of colonization processes, post-depositional selection, wintertime activity and microbial redistribution within snow packs is of crucial importance to understand biological activity in Arctic systems. Microorganisms in Arctic environments are still the unknown variable in the climate change equation.



1210 IVORY

IN SEARCH OF IVORY GULL: A SENTINEL SPECIES OF CLIMATE CHANGE IN THE MOST THREATENED AND REMOTE AREAS OF GREENLAND.

Species living in the Arctic are facing strong environmental changes. Forecasting impacts of such changes on endemic Arctic species require a full understanding of their ecology and habitat requirement. A limited number of sea ice associated Arctic species act as sentinel species, whose ecological responses to the consequences of environmental modifications deserve special attention. This is the case of the Ivory Gull (*Pagophila eburnea*), a species that entirely completes its life-cycle in the Arctic and is thus directly facing impacts of the Arctic alteration. Here, we propose to use complementary approaches to investigate the demographic trend, change of space use and contaminant load of Arctic species under climate change and other environmental modifications (i.e. an increase of bird exposure to contaminants), with Ivory Gull as case study species. We will combine a genomic approach (high-throughput sequencing) to infer population dynamics and population genomic structure with GPS tracking used to infer movements and habitat selection of Ivory Gull throughout its distribution range. In addition, we will assess the contaminant loads of ivory gulls in its last Greenlandic breeding strongholds. Our complementary approach will produce fundamental biological information for the conservation of the Ivory Gull in the context of climate change and of the planned exploitation of its offshore feeding grounds.



1218

HYPERGESE

HYPER-ABUNDANT ARCTIC-NESTING GEESE AND THE DECLINE OF CANADIAN ARCTIC-NESTING SHOREBIRDS, AN EMPIRICAL TEST.

Arctic ecosystems are far removed from the direct effects of the soaring human population because they are remote and sparsely inhabited. However, ironically, trends in recent decades suggest that Arctic ecosystems may undergo the fastest and most radical changes on the planet as a consequence of human activities. This is in particular because of their sensitivity to current anthropogenic changes in global climate. These climate induced changes in Arctic ecological conditions have rightfully attracted the attention of the research community. However, this focus comes at the expense of research on other forms of anthropogenic disturbance in the Arctic. One of the most dramatic examples is the explosion of arctic-nesting snow geese populations. Their numbers soared from less than 100 000 individuals to possibly over 10 million in only a small number of decades. This resulted from changes in agricultural practices and of the ability of these species to shift their wintering grounds to these novel, man-made habitats. The focus of this proposal is to repeat detailed, ground-based data collection carried out 22 years ago, to evaluate the cascade of changes in habitats and avifauna that have occurred, and the role played in these changes by changes in the intensity of goose grazing and climate.



EARTH AND SPACE SCIENCES



1026 POLARIS3

POLARISATION OF THE THERMOSPHERIC RED LINE IN SVALBARD

This proposal is an extension of the proposal 1026. After a series of discoveries and a first wintering at Ny Alesund, it is now desirable to perform long term measurements of the red line polarisation. Long term means at least over $\frac{1}{2}$ a solar cycle (about 6 years) from the same observation position. The goal is to link the polarisation to the solar activity to make it a new space weather window on our space environment. We already have a few months from Hornsund, and a few months from Ny Alesund. We propose here to complete this series of observations for the next 4 winters at Ny Alesund.



- AWIPEV Ny-Ålesund, Svalbard ARCTIC
- Lilensten Jean

1042

ESCAPE2-ARCTIC

ECOSYSTEMS - SNOW - CLIMATE PERMAFROST FEEDBACKS - 2

Permafrost covers over 20% of land masses in the Northern hemisphere. Its thawing due to global warming could release tens of Pg of carbon in the form of CO₂ and CH₄ to the atmosphere, representing a major positive feedback to warming. Permafrost thawing also impacts Northern communities and on the development of the Arctic. This project aims at improving:

- Our prediction of the evolution of the thermal regime of permafrost;
- Our understanding of the exchanges of carbon between the permafrost and the atmosphere.

Regarding the first question, the emphasis will be placed on snow-vegetation interactions, and in particular on the physical processes induced by vegetation growth and which modify snow thermal conductivity, in order to pursue and complement the breakthroughs of the past 4 years. Regarding the second question, the emphasis will first be placed on the Umiujaq site, where the ground is carbon-poor and where vegetation growth has allowed recent carbon uptake. Subsequently, the carbon-rich Bylot site will be studied.

1126

ARCSNOW

LONG-TERM INTERACTIONS BETWEEN SNOW AND THE ATMOSPHERE IN THE ARCTIC

Climate assessments consistently reproduce zonal mean surface temperature warming in Arctic latitudes exceeding the global average. This Arctic Amplification was initially attributed to snow/ice albedo feedbacks, but progressing climate modeling revealed several other feedbacks playing a role as well. These include effects due to modified thermal properties of sea ice or changes in poleward energy transport and associated shifts in storm tracks, vapor and clouds. These findings are mostly based on climate modeling, but their validation by observations as well as the assessment of the relative importance of inherent processes remains difficult and is still quite controversially discussed. Based on this background, this project seeks to investigate the role of long-term snow developments and of inherent feedbacks due to e.g. changes in snow structure and snow albedo in Arctic Amplification in more detail. Albedo changes are at least partly related to the incorporation of light absorbing impurities and, thus, the chemical composition of the snow. Therefore, a second objective is related to a better understanding about chemical interactions between the atmosphere and the snow including pollutant wet/dry deposition and pollutant recycling at the snow/ice-atmosphere interface.



Canada, Nunavut et Nunavik
ARCTIC

Domine Florent



AWIPEV Ny-Ålesund, Svalbard
ARCTIC



Jacobi Hans-Werner

1141

AWIPEV-CO2

MONITORING OF THE CARBONATE CHEMISTRY AT THE AWIPEV UNDERWATER OBSERVATORY

In its first phase, the AWIPEV-CO₂ project set-up a time-series of carbonate chemistry parameters at Ny-Ålesund. It is the first (and only) such series in the Arctic Ocean. These data are required to estimate air-sea CO₂ fluxes, the rate of ocean acidification, and plan future perturbation experiments following those conducted in 2009 and 2010. An ERC project has been submitted. Four instruments have been set-up as part of the AWIPEV Underwater Observatory: pCO₂ (2015), total alkalinity (2016), in situ pH (2017) and pH in the Ferrybox (2017). Beside IPEV, these activities have been financially supported by the AWI and the European project INTAROS. Discrete samples are collected weekly (dissolved inorganic carbon and total alkalinity) as well as monthly (pH) to calibrate the sensors and perform quality-control. The data are available in near-real-time (http://www.obs-vlfr.fr/~gattuso/data/awipev-CO2_web.html). We are seeking the continuation of this time-series.



AWIPEV Ny-Ålesund, Kongsfjord
ARCTIC

Gattuso Jean-Pierre



1180

EGRIP-FRANCE

ICE DRILLING IN GREENLAND EGRIP - FRANCE

This project represents the French contribution to the international deep drilling project EGRIP (East Greenland Ice coreProject) with the target of studying the dynamics of the large North East Greenland Ice Stream (NEGIS) and recover a high-resolution climatic archive of the last 50.000 years: access to the drilling site, to the ice samples and contribution to the deepdrilling operation.



Groeland
ARCTIC

Gillet-Chaulet Fabien



1206

INTAROS-SVALBARD

CONTRIBUTING TO AN INTEGRATED ARTIC OBSERVATION SYSTEM AROUND SVALBARD

The Arctic is undergoing the most rapid changes among all regions on the Earth. These changes, including the rapid sea ice decrease and air temperature warming, are affecting the Arctic ecosystems in terms of functioning, geographical distribution and communities. They are also suspected to influence the Northern Hemisphere atmospheric circulation and the European Climate. Increasing the in-situ observing capacity in the Arctic has become a major challenge owing to the current lack of data, mostly due to the difficulty in accessing these remote and harsh environments. The INTAROS-Svalbard aims at strengthening the observing capacity in a very important region of the Arctic with regards to on-going changes, the Svalbard region. This initiative is part of a wider one that is currently set-up within the EU-H2020 INTAROS (INTegrated Arctic Observation System) project. The ocean around Svalbard is a key-region for the Arctic climate, as it is a major pathway for the warm Atlantic water entering the Arctic Ocean, an area of intense ocean-ice-atmosphere interactions and a transition region between two very distinct Atlantic and Arctic biogeographic provinces.

The main objectives of the INTAROS-Svalbard project are:

To better understand and monitor the environmental conditions which control the redistribution of the heat content of the Atlantic water inflow to the Arctic Ocean through Fram Strait, its links to sea ice and the thermohaline structure of the upper ocean in the region west and north of Svalbard

To better understand and monitor the interactions between waves and sea ice in the coastal zones of west Spitsbergen focusing on a major fjord, Kongsfjorden

To characterize the response of the biology and behavior of zoobenthic populations to sea ice evolution and hydrographic conditions in Kongsfjorden.

To achieve these objectives, gliders will be deployed in summer in Fram Strait and north of Svalbard. These high resolution measurements will provide a detailed characterization of the summer hydrography, hydrodynamical properties and mesoscale activity associated with the Atlantic inflow in the region extending across the western Spitsbergen slope and beyond. Mooring lines deployed on the northern slope of Svalbard will provide multi-year time series of current and water properties, helping to understand the link between the sea ice distribution, the upper ocean properties, the current dynamics and the cross slope exchanges. In Kongfjorden, passive acoustic signals recorded by hydrophones and measurements by accelerometers which will be installed on benthic bivalves will be used to monitor the biological activity. The separation of the acoustic signals between its biological and abiotic origins will allow to understand the biological activity in relation to the sea ice evolution and other environmental parameters. Wave-sea ice interactions will be investigated from the acoustic records and high resolution SAR imagery.



AWIPEV Ny Alesund,
Kongsfjord, Svalbard
ARCTIC

Houssais Marie-Noëlle

1207 MESSI

**MERCURY STABLE ISOTOPES
IN THE ARCTIC ATMOSPHERE**

Mercury is toxic to both wildlife and humans and is transported to arctic ecosystems via air, rivers and oceans. During recent ERC, CAF, and H2020 projects we have made new and critical observations on arctic mercury cycling, including the first seasonal observation on russia river inputs, on open Arctic Ocean mercury speciation and distribution and on tundra uptake of atmospheric mercury. These results are stimulating a rethink of arctic mercury cycling and the development of a new generation of numerical models that help understand how arctic warming affects mercury cycling and exposure. One key observation, the elevated summertime atmospheric elemental Hg levels, remains ill-understood. The main objective of the MESSI project is to make novel observations of the mercury isotope signatures of the summertime peak, in order to understand its origin (terrestrial, marine, sea ice?). In addition we will revisit seasonal atmospheric reactive mercury (HgII) dynamics by intercomparing novel sampling methods to current mercury monitoring instruments. The new observations should help better parameterize coupled 3D models of the arctic mercury cycle.



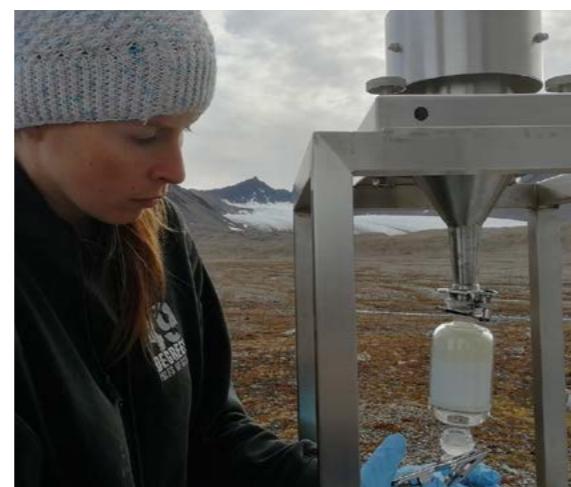
**AWIPEV / Ny-Alesund,
Greenland / Station Nord, Océan Arctique
ARCTIC**

Sonke Jeroen

1215 ALPACA

**ALASKAN POLLUTION ARCTIC
CHEMISTRY-CLIMATE ANALYSIS**

The main objective of the ALPACA (ALaskan Pollution and Chemical Analysis) project is to gain new insights into the processes governing the formation and distribution of aerosols originating from local pollution sources in the Arctic during wintertime and early spring. For this purpose, this project makes a major contribution to, and benefits from, a major international field campaign being planned in Fairbanks, Alaska during winters 2019/20 and 2020/21 as part of the international programme ALPACA (supported by IGAC/IASC PACES). A combination of field data collection, chemical composition analysis in the laboratory, analysis of observations and atmospheric modeling will be used to better understand and simulate Arctic aerosol sources, interactions between chemical and dynamical (boundary layer) processes influencing aerosols, and the impacts of aerosols from local anthropogenic sources on climate relative to remote sources of pollutants transported from mid-latitudes (Arctic Haze). This project brings together 7 complementary French groups working on atmospheric chemistry and dynamics together with geochemists working on isotopes. This project requires support for the field campaigns in Alaska.



**Alaska
ARCTIC**

Law Kathy

1216 EXTREMEVENT

**STUDY OF THE IMPACT OF
EXTREME EVENTS ON MORPHOSEDIMENTARY
CHANGES IN ICELANDIC COASTS**

The project EXTREMEVENT is conducted through the problematic of global warming that would have as supposed impacts, an increase of the frequency and/or intensity of storm events at medium and high latitudes. In that context, the study of coastal morphodynamic processes on the peninsula of Reykjanes (SW Iceland) is proposed. It is based on the annual monitoring of a dozen coastal sites corresponding to rocky coast where cliff-top storm deposits (CTSs) are accumulated, and accumulation forms such as boulder beach and dunes. Therefore, CTSs carrying, transport and accumulation, and boulder beach and dunes erosion by giant storm waves are interpreted as proxy of extreme events on the dynamics of the Icelandic coasts. Comparisons with the dynamics observed on the lower latitudes of Brittany are realized through the French Service National d'Observation SNO-DYNALIT funded by the CNRS-INSU. The survey is based on topo-morphological measurements using KAP and UAV aerial images, and DGPS field measurements; it is also based on hydrodynamic analysis using wave and tide measurements. This project was completed over a period of 4 years - 10 days of field campain during spring period (mid-May 2019, 2020, 2021, and 2022), to accommodate the longest survey period. Staff travel, material transport, consumable (car location), and field and running costs for 3 persons (researchers and engineers) are requested to IPEV for a total budget of 6,350 euros per year. Original scientific outputs (i.e. articles and conferences) on aspects that are not studied in Iceland yet, and scientific and educational strengthening collaboration with the University Centre Of The Westfjords, are expected.



**Islande, Péninsule de Reykjanes
ARCTIC**

Suarez Serge

1222 ICEWAVEGUIDE

**MONITORING SEA ICE THICKNESS
AND RESILIENCE WITH SEISMIC NOISE:
A PROOF OF CONCEPT AT SVALBARD**

The decline of Arctic sea ice extent is one of the most spectacular signatures of global warming, and studies converge to show that this decline has been accelerating over the last 4 decades, with a rate that was not anticipated by forecasting models. In order to improve these models, relying on comprehensive and accurate field data is essential. While sea ice extent and concentration are accurately monitored from microwave imagery, we are still lacking an accurate and comprehensive measure of its thickness. In addition, models could benefit from including other observables related to the ability of the ice cover to resist cracking and to heal/reform when cracking occurs. The ICEWAVEGUIDE project introduces a methodology based on seismic waves propagation to meet these needs, and aims at completing current knowledge so far acquired mostly from Radar and Sonar data. Based on continuous, passive recordings of seismic ambient noise at an array of geophones, the ICEWAVEGUIDE project will demonstrate that propagation of leaky seismic waves guided in the thickness of the ice can be measured. Guided waves being sensitive to the geometrical and mechanical properties of the waveguide, the measures will be inverted to recover important markers of ice mechanical resistance, such as thickness, elastic properties and damage level. This new methodology was successfully tested on data acquired in a lab-scale experiment. The experiment consisted in leaving a water tank in a cold room so as to grow an ice layer at its surface. While its thickness was increasing, ultrasonic guided waves were generated in the ice with a piezoelectric source, and measures were subsequently inverted to monitor the thickness and mechanical properties of the ice. The goal of the proposal is to extend this proof of concept on actual geophysical data acquired on a frozen lagun in Svalbard (Norway) during winter 2019.



**Svalbard, Vallunden,
Svea dans le Fjord de Van Mijen
ARCTIC**

Moreau Ludovic

1224 [MPC]2

MICROPHYSICAL PROCESS CHARACTERIZATION OF MIXED PHASE CLOUDS IN THE EUROPEAN ARCTIC.

The Arctic is warming at twice the global mean rate and shows acute visible signs such as the retreat of summertime sea-ice. The predictive capability of Arctic response to climate change is severely hampered by a lack of understanding on key processes related to clouds. Observations suggest that boundary layer mixed phase clouds (MPC, mixture of liquid droplets and ice crystals) are ubiquitous in the Arctic and persist for several days under a variety of meteorological conditions. The strong impact of MPC on the energy budget stems from their persistence and peculiar microphysical properties which result from a complex web of interactions between local microphysical, radiative, dynamical processes and larger scale environmental conditions and processes. Within the (MPC)2 project, we plan to provide and analyse high quality cloud data to quantify the impact of the microphysical properties of MPC on the surface energy budget and to better understand the life cycle of the mixed phase. The proposed work mainly relies on the statistical analysis of the in-situ cloud microphysical and optical measurements collected during ACLOUD 2017, AFLUX 2019 and MOSAiC 2020 airborne arctic campaigns in the vicinity of the Svalbard Archipelago. State of the art in situ instrumentation (cloud and aerosol) along with airborne remote sensing devices will be used to characterize the spatial distribution of cloud microphysical properties as a function of large scale meteorological and surface conditions as well as aerosol concentrations. We can expect to collect comparable dataset of cloud properties during summertime and springtime to study the influence of environmental properties on the vertical profile of microphysical properties. This new dataset will contribute to the development of cloud parametrizations for models and satellite retrievals and to increase our process level understanding of cloud microphysics.

1227 PIM

PARTICIPATION OF IAOOS IN MOSAIC

Autonomous, integrated atmosphere-ice-ocean buoy systems (IT buoys) have been developed within the IAOOS program to provide year-round ocean-ice-atmosphere integrated observations over the Arctic Ocean. These systems allow an in-depth study of local processes. Satellite observations allow additional synoptic insight and are further needed to connect observational scales. In the frame of the next MOSAiC international campaign (SHEBA follow-on 20 years after), a unique scientific deployment will be performed based on the Polarstern drift from the Siberian sea to Svalbard in 2019 and 2020. We will participate to MOSAiC with IAOOS platforms and intend to integrate new instruments to study key local and regional processes (combining IAOOS with satellite observations) involving sea-ice-atmosphere-ocean interaction. The main focus of the present proposal is to support our participation, data transfer and archival, and the analysis of the extensive datasets within this international collaboration. The Year of Polar Prediction (YOPP) and EU projects such as APPLICATE, are important partners for connecting our results to large scale modelling applications.



Arctique central
ARCTIC

Provost Christine



AUWIPÉV Ny-Ålesund, Svalbard
ARCTIC

Jourdan Olivier

HUMANITIES AND SOCIAL SCIENCES



1038

PALAEOMICS I

UNVEILING THE BIOLOGICAL CONSEQUENCES OF POPULATION CONTACT AND RESULTING CHANGES IN LIFESTYLE IN NORTH EAST SIBERIA : AN ARCHAEOLOGICAL, PALAÉOGÉNOMIQUE, EPIPROTEOMIC AND MICROBIAL APPROACH

Our project will focus on tracking the genetic, epigenetic, and microbiota changes experienced by the Sakha people (Yakuts) in Far Eastern Siberia, following contact with Russians from 1632. Prior to Russian contact, native Yakuts had never been exposed to germs such as smallpox and tuberculosis. The arrival of Russians in the region resulted in massive epidemiological outbreaks, which decimated the population. Likewise, the Yakut traditional diet was also transformed to include more carbohydrates, derived from the newly introduced cereals and potatoes. Therefore, Russian contact kick-started, as early as the 17th century, a series of deep transformations in the Yakut society, which continued in the following centuries with the rise of the Soviet Union in the early 1900s and the emergence of antibiotics after 1950. Our project associate: (i) The excavation of frozen grave from periods and/or sites which has never been excavated before and that we expect that they will furnish unexpected results about the history of population of this part of the world. (ii) The study of biological modifications experienced by human groups following population contact and change in

lifestyle at three levels, genomic, epigenetic and microbial level. The samples that will be studied include the human sample excavated from 2002 to 2015 and the new ones that we excavate and which are susceptibility to change the history of the population of this part of the world and of the arctic.



Russie
ARCTIC

Crubézy Éric

1080

ENCHAINEC

ENVIRONMENTAL CHANGES AND HUMAN ACTIVITY IN NORTH EASTERN CANADA (NUNAVIK AND LABRADOR) DURING THE LAST MILLENIUM

The ENCHAINEC project is focused on vulnerability, resilience and adaptation of northern societies facing global change. The rapid current warming of Arctic climates has already created many changes in the social, economic and cultural behavior of the populations inhabiting these regions and more changes are expected to come. These changes disturb the fragile balance between human and the environment. Populations of these areas have to face these challenges, and in this context, looking at the past provides the opportunity to explore the complex relationships between climate, ecology and human societies, which may help to suggest scenarios about some situations according to the forecasts. The chronological frame of the project encompasses the last millennium, a pretty well documented period. The study area concerns North-Eastern Canada (Nunavik, and Labrador-Nunatsiavut). Around 1000 years cal. AD, hunters/gatherers/fishers lived by the Nunavik and Labrador coasts. Within these study areas, our aim is to document 1000 years of interactions between Thule/Inuit (last Dorset pro parte) people, and their environment, through an interdisciplinary approach exploiting different kinds of natural archives. The use of pedo-sedimentary archives (lake and peat deposits, cryosols, anthroposols) and palaeoenvironmental multiproxy analyses will give useful information about landscape evolution, climatic and anthropogenic forcings upon ecological processes. Archaeological sites, and more specifically archaeological soils, ecofacts and artefacts, will give precious information about the nature of these

interactions. In parallel when possible, an anthropological/cultural approach through open interviews will focus on human memory of Inuit elders, perception and prospects of environmental and social changes.

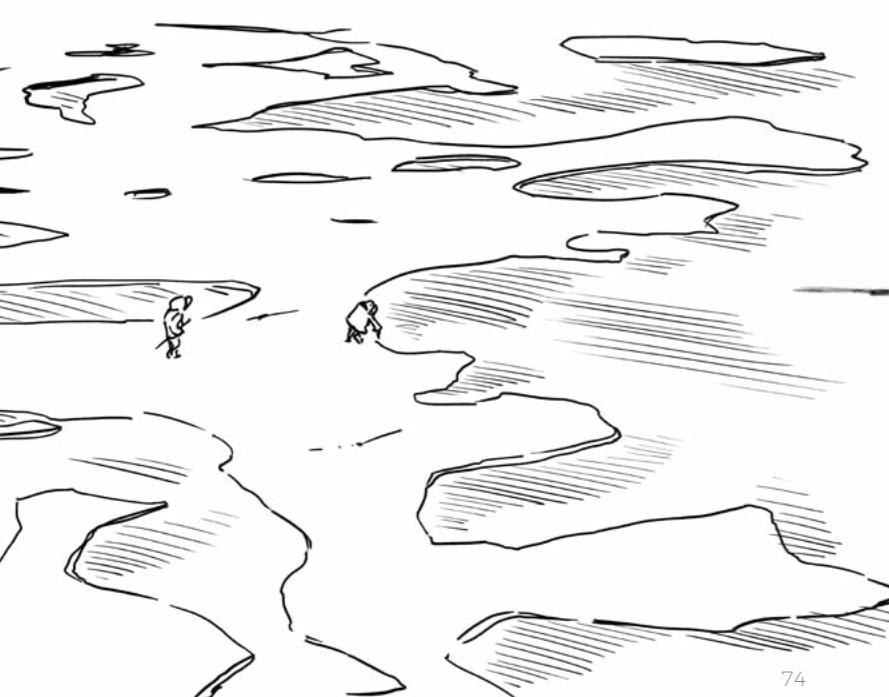
Several modes of communication have already been identified, adapted to the different audiences and partners involved in the project: academics (presentations at conferences and publications in international journals), local communities and local authorities. It is a priority for us to circulate the results of our field work and analyses to a non-specialist audience, especially youths of the Inuit communities, by a website featuring the innovative interactive platform and the Facebook page.



Canada / Nunavik, Labrador
ARCTIC



Marguerie Dominique



1108

AUSTRE LOVÉNBREEN - SNOW AND ICE (ALSI)

AUSTRE LOVÉNBREEN - SNOW AND ICE

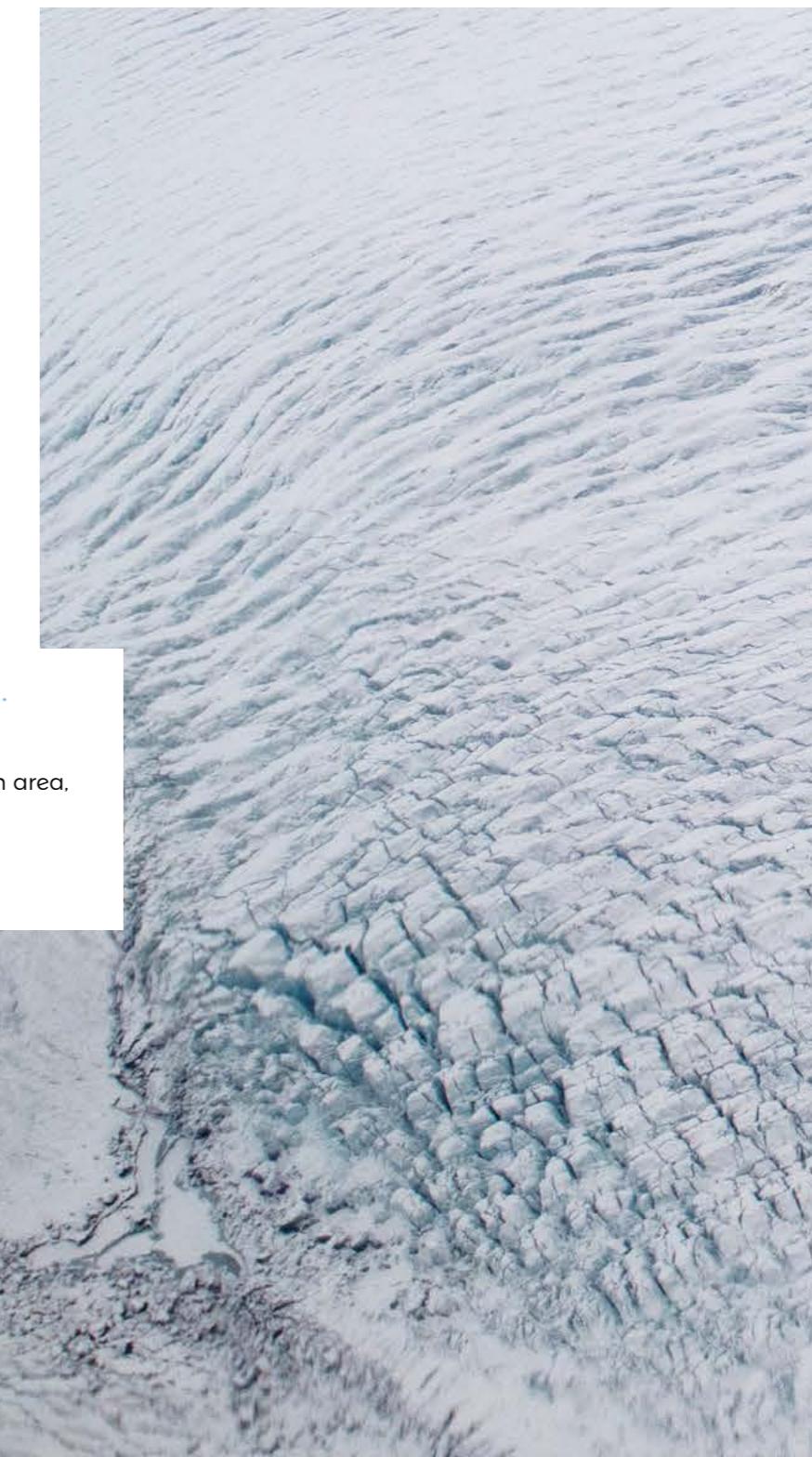
The ALSI project is aiming at consolidating the basin of the Austre Lovén glacier as a long-term observatory. Such observatories are scarce in the Arctic and the data they provide are therefore all the more valuable. While the first observations in this basin were conducted in the 1960's, a renewed effort has been undertaken by our team amounting this year to a decade of data. This work consisted for some part in applying standardized protocols for glacier mass balance measurements, and for another part in instrumental experimentations and developments such as automatic cameras. As of today, recurrent measurements led on the glacier are now part of the national SOERE CRYOBS-CLIM, recently integrated in the newly created IR OZCAR, and at the international level part of the World Glacier Monitoring Service (WGMS) database. The observation network is now operational in the field and benefits of the 10 years of experience our team holds. Keeping these measurements going can be done at minor human and financial costs. We are encouraged by our international scientific community to continue our efforts as the Austre Lovén glacier basin holds specific characteristics that makes it of particular interest in a global glaciological and hydrological approach.



AWIPEV, Ny Alesund / Kongsfjorden area,
Austre Lovén glacier catchment
ARCTIC



Bernard Éric





1127 BRISK'S OBS ENV

OBSERVATORIES FOR BRIDGING INDIGENOUS AND SCIENTIFIC KNOWLEDGE ABOUT ENVIRONMENTAL CHANGES IN THE ARCTIC: ADAPTATION AND VULNERABILITIES OF THE ENVIRONMENT AND RELATED SOCIETIES

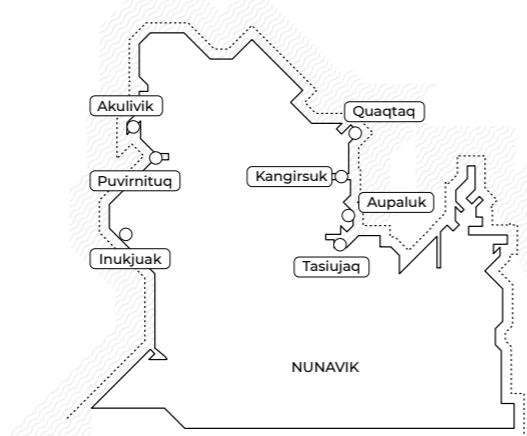
BRISK's OBS ENV is the continuation of BRISK's OBS (2014-2017). It is constituted by four Siberian transdisciplinary observatories among Evenki reindeer herders and townspeople. The installation, development, data production and analysis were jointly conceived by scientists (natural and social) and indigenous peoples.

It assesses local environmental changes and related socio-economic impacts in the current context of the interplaying global environmental crisis, geopolitical interest in the Arctic's resources and increasing Arctic pollution.

Based on the complementarity of indigenous and scientific knowledge, and in accordance with the COP21 agreement, it aims to build synergies between the natural and social sciences, between science and indigenous knowledge and between indigenous communities, scientists and policy-makers. This innovative methodology allows knowledge co-production that contributes to filling gaps about the Arctic environment and its current changes. Also, classical anthropological methods are used to study socio-economic impacts on the societies concerned and their adaptive strategies. It includes a study of changes in biodiversity (appearance and disappearance or increase or decrease of animal and vegetal species). Secondly, it considers pollution by monitoring human sensory perceptions, new reindeer illnesses and lichen evolution. Thirdly, it provides a cloud atlas in order to document the Arctic cloud cover and air pollution.

1148 DESIGN

DYNAMIC SLOPE GEOMORPHOLOGY AND VULNERABILITY IN NUNAVIK, CANADA



Several of the villages and parks in Nunavik (northern Quebec, Canada) are located close to high reliefs where slope record frequent gravity movements. In such setting, providing data regarding landforms, their dynamics and induced risk for a growing local population and even more numerous tourists years after years within the parks are requested. The first objective of project DeSiGN is to improve the slope dynamic knowledge over long-term and mid to short-term periods in a global warming context. The second objective is to characterize both hazard and vulnerability, to define and quantify risk due to slope dynamics. To reach these objectives, we privilege a methodology based on field techniques offered by geomorphology and stratigraphy, and lab analyses (dating, sedimentology, dendrochronology).



Russie
ARCTIC

Lavrillier Alexandra



Canada
ARCTIC



Decaulne Armelle

1208

BOAZU

A SAMEBY-DRIVEN RESEARCH PROJECT INVESTIGATING THE CUMULATIVE IMPACTS OF ENVIRONMENTAL AND SOCIAL CHANGE ON REINDEER HERDING AND THE FUTURE FOR SAAMI YOUTH

Reindeer herders today face many challenges, including climate change (resulting in later springs and colder summers), high rates of predation on young calves, and restricted access to land due to increased encroachment (by mining, wind farms, hydroelectric dams and tourism). Given these concerns about their future, they wish to better understand how the cumulative effects of these changes are currently affecting the reindeer-herding economy and lifestyle, the land, as well as their future impact on Saami reindeer-herder culture and language.

When they finish school, young Saami students have to make choices based on what they believe the future holds. Would their best prospects be in mining, tourism, or other jobs combined with reindeer herding?

To address these issues, a proposal for an initial research project was drafted in July 2017 during a series of workshops with the Jåkkåkaska Sameby at the reindeer-marking camp in Arasluokta. The project, aimed at exploring options and possible future scenarios, will be led by Sameby members and students at the Saami school in Jokkmok, working with a team of researchers from universities in Sweden, Norway, Finland and France. In this way, Saami schools, Sameby members and academics will join forces to develop an integrated, interdisciplinary, collaborative participatory-action research program to explore the issues and priorities and develop an action plan. This approach

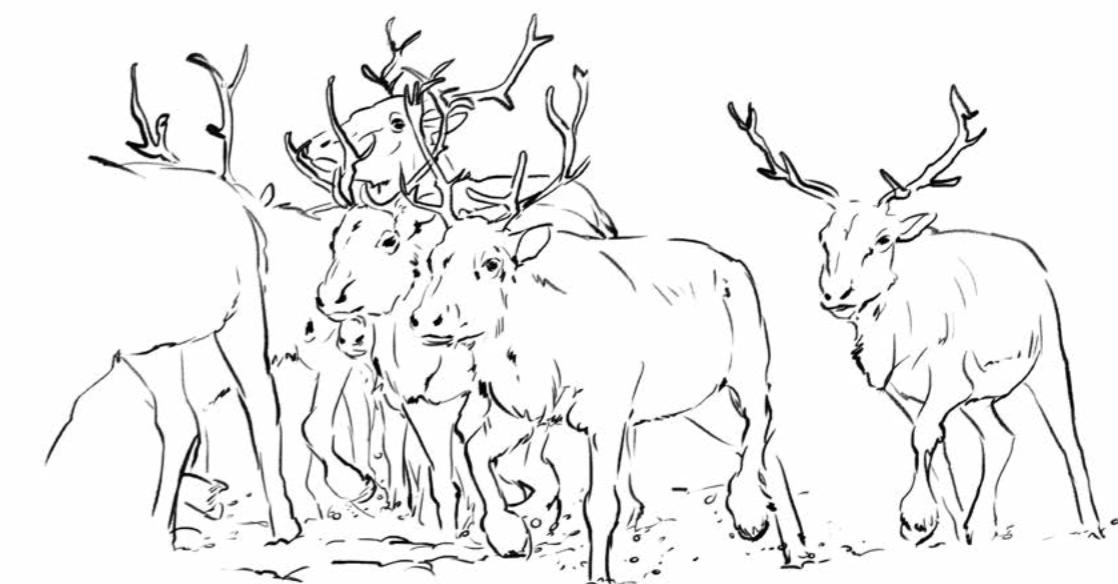
will bring together local expertise and scientific knowledge in order to better understand the magnitude of changes, to analyze their impacts, and to envision the scenarios for the future. The Saami of Sapmi seek an overall view of the changes taking place rather than dealing with one question at a time. BOAZU stands for «reindeer» in Saami.



Suède / Jåkkåkaska sameby
ARCTIC



Blangy Sylvie



1213

IMOB-ED

INUIT MOBILITY AND EDUCATION

This research project aims to study the conditions of admission and academic success of Greenlandic students in migratory situations, mainly through qualitative research. Focusing on the conditions of their mobility (about the way people change location as part of their studies and about its impacts), the study will rely on a two-fold methodology: participant observation field-notes on the one hand, analysis of a corpus of interviews on the other.

To identify how the double process of subjectivation and emancipation at work in education related mobility, we will investigate the journeys and experiences of Greenlanders who have moved to Copenhagen to study. As keys to better appreciate their stories, special attention will be given to a historical situation of colonial domination that still pervades Greenlandic society, where race and culture are central issues, as well as to the global context in which such mobility takes place today - commodification of higher education in relation with the rise of the "economy of knowledge" and a high variability of migrants' social inclusion according to their country of origin. We will examine how students resist norms foreign to them, open spaces for their own fulfilment, rely on social and political networks to support their educational trajectories. Hence, this research will draw a social geography of access to a University diploma for minority groups that are such both in their own country and in the academic world.

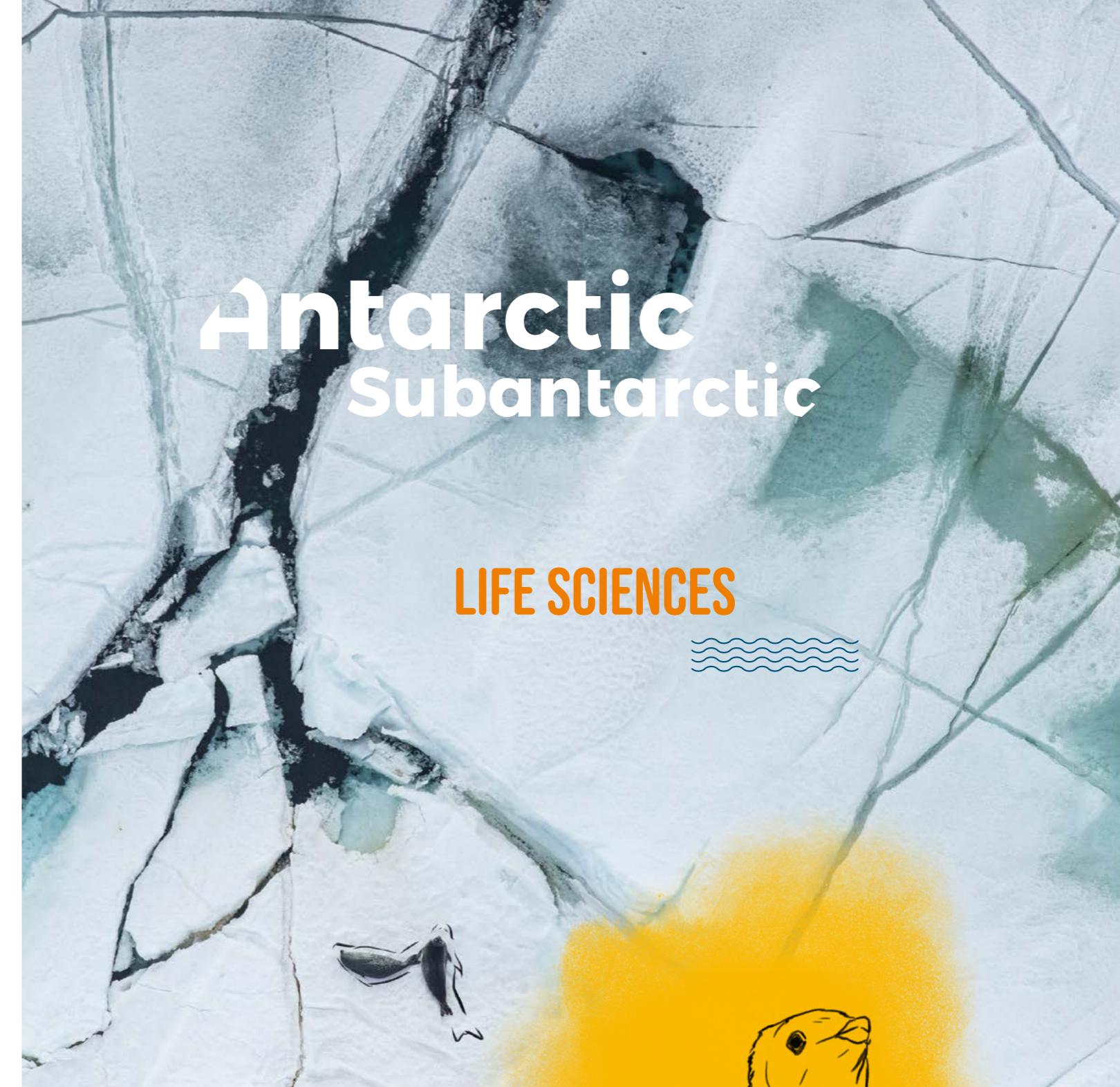
Fieldwork will be conducted both in Copenhagen, where Greenlanders come to study, and in Nuuk (Greenland), where they depart from and return to. To put this study into perspective, a secondary and minor research will consider the Canadian Inuit situation. Mainly based on an analysis of already available quantitative data, it will also include a limited case study based on in-depths interviews with those who choose to study at Whitehorse Yukon College.

1217

PALETHNOAK

PALETHNOLOGICAL APPROACH TO PREHISTORIC HUNTER-GATHERERS FROM THE ALASKAN BOREAL FOREST

The Nenana valley near Healy, Alaska, has been the site of many decades of prehistoric archaeological research focused on the late Pleistocene and early Holocene records, thus documenting the initial settlements of humans in the New World. New research at the Little Panguingue Creek site (HEA-038) will provide us with important information about Pleistocene-Holocene human activities in the Nenana valley foothills. This multi-component site is located on a Healy-aged glacial-outwash terrace, overlooking Little Panguingue Creek. A new multi-year excavation program, began in 2015, revealed a c. 9,600 cal yr BP knapping workshop (hammerstones, cores, preforms, cortical spalls, tools, debitage, etc.) with a major microblade component dating from the final phase of the Denali Complex, along with an older component dating to c. 11,150 cal yr BP. The on-going research at the site will further our understanding of human technological, subsistence, and settlement organization in the Nenana valley (and beyond) during the Pleistocene/Holocene transition. One of the main objectives of this project is to develop a paleoethnological approach to this site. In other words, not simply understanding the chrono-cultural complexes present, but understanding this campsite in detail. In order to do this, we have planned extensive excavations, new surveying techniques (GPR, magnetic, etc.), and the application of specific disciplines (lithic technology, raw materials provenience, use-wear analysis, spatial analysis, refitting, etc.).



Alaska
ARCTIC



Coutouly Gomez
Axel Yan



Groenland, Nuuk
ARCTIC



Collignon Béatrice



109

ORNITHOECO

SEABIRDS AND MARINE MAMMALS AS SENTINELS OF GLOBAL CHANGES IN THE SOUTHERN OCEAN

The program uses seabirds and marine mammals as indicators of global changes in the marine ecosystems of the southern ocean. Through a network of 4 observatories from the Antarctic to sub-tropical biomes, the populations of 25 species of marine top predators and their distribution at sea are monitored since 50 years. These individually based long term information, combined with shorter term studies carried out on an annual base, especially on the foraging ecology of the species, are used to understand the processes through which climate affects marine ecosystems, and to make predictions on the effects of future changes in these ecosystems, as well as to propose conservation measures to limit the impact of fisheries on populations.



Terre Adélie, Amsterdam
St Paul, Crozet, Kerguelen,
ANTARCTIC, SUBANTARCTIC

Weimerskirch Henri

119

ECONERGY

INTERACTIONS BETWEEN EXTRINSIC AND INTRINSIC FACTORS IN SHAPING OFFSPRING GROWTH AND ADULT PHENOTYPE: DETERMINANTS OF INDIVIDUAL QUALITY IN THE KING PENGUIN ?

Our research program ECONERGY is devoted to the study of the physiological, energetic and evolutive aspects of the so-particular adaptations exhibited by adults and king penguin chicks (*Aptenodytes patagonicus*) to their ashore living stages. These are characterized either in chicks by their extraordinary long growth period and the irregular feeding rates during the winter or in adults by their long-term fast during reproduction or molting. To answer our questions we realized studies via the study of the animal in his environment with an ecophysiology approach



Crozet
SUBANTARCTIC

Robin Jean-Patrice



131

PHYSIONERGY

ENERGETIC CHALLENGES IN PENGUINS: PHYSIOLOGICAL, BIOENERGETICS AND MOLECULAR ADJUSTMENTS

Because they have optimized the bioenergetic processes essential for their survival, marine birds from the polar and subantarctic regions are of outstanding interest. By an integrative physiological approach from the entire animal to gene expression, the deciphering of the adaptive energetic mechanisms developed by polar species at each critical steps of their living (reproduction, hatching, thermal emancipation) could improve our understanding and reveal potential targets for metabolic diseases.



Crozet
SUBANTARCTIC

Roussel Damien

136

SUBANTECO

SUBANTARCTIC BIODIVERSITY, EFFECTS OF CLIMATE CHANGE AND BIOLOGICAL INVASIONS ON TERRESTRIAL BIOTA

The subantarctic islands are amongst the most isolated islands from any continental landmass and contain a number of the limited terrestrial habitats present at these latitudes. Interestingly, our knowledge of the subantarctic biodiversity, autoecology and effects of climate changes and biological invasions still contain many gaps. In parallel, accurate assessments of the sensitivity and vulnerability of polar organisms must be achieved in order to reliably predict species and community trajectories. In addition to climate changes, alien insects and plants can represent significant drivers of community structure and functional diversity in general. Changes in plant communities have strong bottom-up effects on multitrophic interaction networks with subsequent effects on above-ground animal

communities in terms of abundance, taxonomic and functional diversity. In this project, we are investigating the spatio-temporal patterns of the subantarctic biodiversity, biological invasion processes, the effects of changing environments and multi-stress on species physiological ecology and the perception of the biodiversity in a non-market context.



Crozet, Kerguelen
SUBANTARCTIC

Renault David

137

ECOPHY - ANTAVIA

ADAPTIVE STRATEGIES AND POPULATION DYNAMICS OF PENGUINS UNDER ENVIRONMENTAL CONSTRAINTS

Assessing the ongoing and future adaptive capacities of populations to cope with global changes is a major challenge. Relying on multi- and trans-disciplinary expertise, P137 has selected three main animal models (and phylogenetically-related top-predators): king penguins *Aptenodytes patagonicus*, Adélie penguins *Pygoscelis adeliae*, and emperor penguins *Aptenodytes forsteri*, to investigate the impact of climate on Southern Ocean ecosystems. Our unique database, without the biasing effects of flipper bands, allows us to study two contrasting, but nonexclusive, mechanisms that can explain their population responses to environmental variability (natural and anthropic): Phenotypic plasticity responses and microevolutionary processes.

In addition to determine and monitor the flexibility and plasticity of numerous phenotypic traits (morphological, physiological, phenological and behavioural; accounting for sex, age, experience, condition, etc.), we also study the spatial structuration of the colonies according to different constraints (social structure, parasitism, predation, local meteorological conditions, etc., but also phylogenetic constraints). We also aim to evaluate the genetic basis of phenotypic traits and their plasticity, and assess genetic diversity and gene flow between colonies within and between archipelagos to gauge their adaptive capacities. The development of new predictive models of population responses to ecosystem changes (models integrating individual-based models within demographic-selection modelling framework, based on scenarios forecast by the IPCC 2014) will be precious tools for population conservation measures and ecosystem management. As never done before, we also propose to develop cutting edge technological innovations to minimize experimental disturbances and resulting scientific bias, such as mobile Radio Frequency Identification antennas on remote-operated vehicles (ROVers), automatic weighing and camera-tracking systems, or networked implanted micro-loggers. In return, it will open new opportunities for science, bringing new research questions that could not have been addressed without these innovations.



354

ETHOTAAF

BEHAVIOURAL ECOLOGY OF SUBANTARCTIC BIRDS

Individuals are programmed to survive, mate, and optimise their fitness. To accomplish these tasks they interact with conspecifics, other organisms, and other elements of their environment. Behaviour thus is the baseline of all animal activities and is continuously modified by cues and clues coming from their environment. Our project merges animal behaviour and sensory ecology, and aims at studying those cues and clues influencing seabirds' behaviour. Signals coming from other individuals broadcast important information for communication. We are particularly interested in the process of mate choice. This behavioural process in petrels passes through acoustic and olfactory signals giving information on direct or indirect (respectively) benefits that a potential partner may bear to the progeny. Signals coming from the surrounding animals may also influence animal behaviour without an actual communication between individuals. For instance, king penguins may use for their orientation an acoustic landscape formed by all individuals calling in the colony. In this case, what is used by an individual is not the information directly broadcasted between two individuals, but the constant noise that all the information broadcasted forms in the environment. To test this hypothesis, we aim to study how this acoustic landscape is formed and whether it is actually used to orient. However, in penguins not only cues coming from other individuals may be important for orientation and positioning. Positioning in the colony and thus survival depend also from predators and other environmental features (waves, temperature, rain, flooding etc.). Ultimately the colony structure may reflect how the birds respond to all the inputs coming from their surroundings. We therefore also need to understand colony formation and dynamics to understand movements of individuals in crowded environments.

394

OISEAUX PLONGEURS

FORAGING ECOLOGY AND ENERGETIC OF SOUTHERN DIVING PREDATORS IN RELATION TO CLIMATIC VARIABILITY

The objectives of this proposal are to study the foraging strategies and energetics of the main diving birds of the Southern Ocean (especially penguins) that play in major role in food webs through a pluri-disciplinary study involving ecologists, physiologist and oceanographers and using bio-logging developments. We want to determine

Their foraging strategies

Their at-sea energetics, from the individuals to the population

To evaluate the consequences of environmental changes on diving birds ecology.

The applied issues concerns the determination of important at-sea birds areas and the use of penguins as indicators of the impact of climatic variability, at short and long term, on some poorly known food webs of the South Indian ocean.



Crozet, Kerguelen, Amsterdam
SUBANTARCTIC



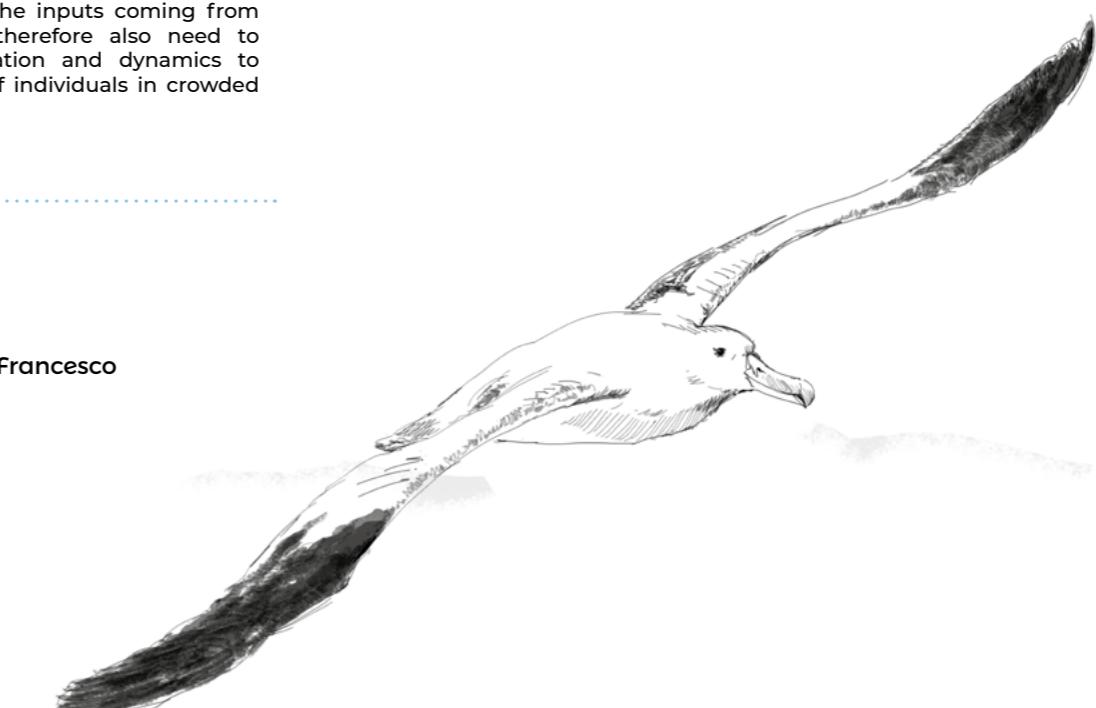
Bost Charles-André



Kerguelen
SUBANTARCTIC



Bonadonna Francesco



1044 PROTEKER

EFFECTS OF GLOBAL CHANGE ON COASTAL MARINE HABITATS OF THE KERGUELEN ISLANDS. ESTABLISHMENT OF A BASE LINE FOR ECOLOGICAL AND GENETIC MONITORING, PROTECTION, AND CONSERVATION

In the current context of climate change, variation of sea surface temperature and salinity, sea level rise and latitudinal shifts of currents and hydrological fronts are expected to affect marine biodiversity of the sub-Antarctic Islands, particularly in coastal areas, in which many species have limited regulatory abilities. Characterizing the impact of climate change on marine communities implies that environmental data must be continuously recorded for interpreting ecological changes, predicting their potential impacts on marine life, and setting up relevant management plans. Such objectives can only be achieved by implementing a long-term and cross-disciplinary observing system. For this purpose, the IPEV program n°1044 PROTEKER was conceived as a multidisciplinary approach including oceanographic measurements, benthic dynamics survey, as well as genetic, trophic, and eco-physiological analyses. The main objective of the program is to establish a base line for assessing the impact of climate change on coastal marine ecosystems of the Kerguelen islands by ecological and genetic monitoring at reference stations and for predicting changes in marine coastal ecosystems as a basis for vulnerability assessments and appropriate management planning. Eventually, the project aims to provide nature reserve managers and decision makers with scientific criteria for protection and conservation of KI coastal marine ecosystems. The program also aims to contribute to the international network of nearshore observing systems in the Southern Ocean (SCAR ANTOS Expert and ISSA Action Groups, IDEAL Center in Chile).

1091 L'AMMER

ADELIE PENGUINS AS MONITOR OF THE MARINE ENVIRONMENT

This program proposal proceeds from the recent international efforts towards long-term monitoring of breeding and at-sea foraging performances of key species serving as eco-indicators of environmental changes. Here, foraging success of these species is linked to physical parameters of their environment and to resource availability. The data collected will consist in identifying the preferred foraging zones of Adélie penguins in Dumont d'Urville, Adélie Land and quantifying the hunting effort according to:

- The availability of their main prey
- Their own ability to find and capture prey, which depends on their individual quality.

In partnership with the WWF, these data will be included in the databases of international programmes of eco-regionalization (Census of Antarctic Marine Life, SCAR, CCAMLR). Comparisons with Adélie penguins' performance in other regions of the East Antarctic sector will be conducted, in collaboration with colleagues from Australian and Japanese polar institutes. Following the recommendations of the aforementioned international institutions, the program will put a special emphasis on the examination of the impact of human activities on penguins' performances through dedicated ecophysiological and behavioural monitoring.



Terre Adélie
ANTARCTIC



Ropert-Coudert Yan



1151 ECOPATH

CIRCULATION OF DIRECTLY TRANSMITTED AND TICK-BORNE INFECTIOUS AGENTS IN SUB-ANTARCTIC AND ANTARCTIC COLONIAL VERTEBRATE POPULATIONS: SURVEILLANCE, UNDERSTANDING AND MANAGEMENT IMPLICATIONS

Describing and understanding factors affecting the distribution and circulation of infectious agents in animal populations is important for basic and applied reasons. Populations of wild vertebrates living in southern polar areas are increasingly the subject of threats from infectious diseases, which can add to other environmental threats, and it is becoming critical to establish baseline data and sound understanding of the dynamics of host-parasite interactions in these systems. In some instance, such information can have clear potential management implications. Populations of vertebrates breeding in colonies are especially important to study in those respects because they are distributed in very discrete units among and within which the transmission of infectious agents can be affected by various processes and can lead to disease outbreaks than can affect hundreds to thousands of individuals at the same time. In this project, we plan to explore how large scale dispersal processes and more local interactions between hosts and parasites can affect the dynamics of circulation of infectious agents and the occurrence of possible outbreaks. In order to do so, we will combine complementary methodological approaches from different fields, involving notably laboratory analyses of biological samples gathered in the field on identified individuals, the implementation of specific field experiments (notably using vaccination) and the parallel development of modelling approaches. Modern molecular techniques as well as tracking devices will be used to address specific questions. The project will rely the results obtained by our team over the previous four years, notably on avian cholera on Amsterdam Island, and on the existing set of long-term IPEV research programmes conducted on various key sites. The work will continue to be conducted in tight coordination with the TAF National Nature Reserve, with specific aspects which have been integrated in the Plan National d'Action Albatros d'Amsterdam and the Plan de Gestion of the Reserve. A specific focus will continue to be developed on infectious agents potentially responsible for large outbreaks, such as avian cholera, as well as on seabird ticks and tick-borne disease agents. Field work is planned to be conducted on the three districts of the French sub-Antarctic islands (Amsterdam, Kerguelen and Crozet), but also in other sub-antarctic areas, in order to address issues at local but also broad spatial scales.



Crozet, Kerguelen, Amsterdam
SUBANTARCTIC



Boulinier Thierry

1182 ASSET

ANTARCTIC SEALS AND THE SEA-ICE ENVIRONMENT

Given the sensitivity of the sea-ice zone to global warming (IPCC 2013), there is an urgent need for determining how top predators use their physical and biological environment, in order to understand and predict their response to climate change in the different Antarctic regions. Events such as calving of large icebergs provide a framework for natural experiments to study the consequences of habitat variations on higher trophic level populations. Because the occurrence of such extreme events around Antarctica is predicted to increase due to global warming, it is now timely to study the ecological response of higher trophic levels to calving of large icebergs and their oceanographic consequences. We propose to take advantage of the unique opportunity offered by the recent Mertz Glacier Tongue calving in Adélie Land (Feb. 2010) to continue an unprecedented time-series on the winter foraging movements and in-situ oceanographic conditions of an ice-dependent top predator, the Weddell seal, spanning over 13 years and encompassing this significant climate event. Using vertical T/S/chlorophyll profiles collected by the seals during their dives in winter, we will link their foraging behaviour to in situ hydrographic conditions before and after the Mertz Glacier calving, and assess impact of the Mertz Glacier calving on ocean/sea ice interactions and primary production in the Dumont d'Urville region, and their potential consequences on the seals foraging behaviour. We will also complete our time-series on the foraging ecology of Weddell seals during summer (post breeding), during which ice retreat stimulates primary production. Finally, we propose to develop new seal-borne sensors to measure otherwise poorly sampled key sea-ice parameters such as sea-ice thickness and sea-ice algae biomass. By so doing, we will simultaneously address urgent questions on upper trophic levels ecology, primary production processes in and below sea-ice, and sea-ice/ocean interactions in an innovative and cost-efficient way.



Dumont d'Urville
ANTARCTIC



Charrassin Jean-Benoît



1201

CYCLELEPH

LIFE CYCLE OF AUSTRAL ELEPHANT SEALS: ENERGY AND PERSONALITY

Links between personality and energetic and behavioural adjustments of Southern elephant seals in response to environmental condition variations during their life cycle

Climate and environmental changes influence the dynamics and structure of marine ecosystems, which affect the distribution and the abundance of marine species. Southern elephant seals (*Mirounga leonina*) may be particularly affected by such spatiotemporal variability, since they alternate between foraging periods at sea and fasting time on land. Different foraging strategies at sea may impact the efficiency with which animals forage, which is the key to their reproduction and moult on land. This work aims to 1) link natural conditions and energetic constraints of a marine predator during its life cycle, alternating foraging and fasting periods; 2) explore whether individual strategies related to personality traits would impact on foraging success, moult speed, and ultimately on energetic and fitness components and 3) extend the environmental and seal behaviour data set through the SO-MEMO program. By exploring both proximate parameters (i.e. physiological, behavioural, energetic strategies) and ultimate (i.e. foraging success, reproductive success, moult speed) of individuals, this work will substantially increase our understanding of how environmental stressors such as ocean warming may influence energy expenditure, energy intake and therefore energy balance of this deep diving predator and how this could be mediated by personality traits.



Kerguelen
SUBANTARCTIC



Gilbert Caroline



EARTH AND SPACE SCIENCES

133

SISMODOLOGIE/OBS

GEOSCOPE - EOST: GLOBAL SEISMOLOGICAL OBSERVATORY

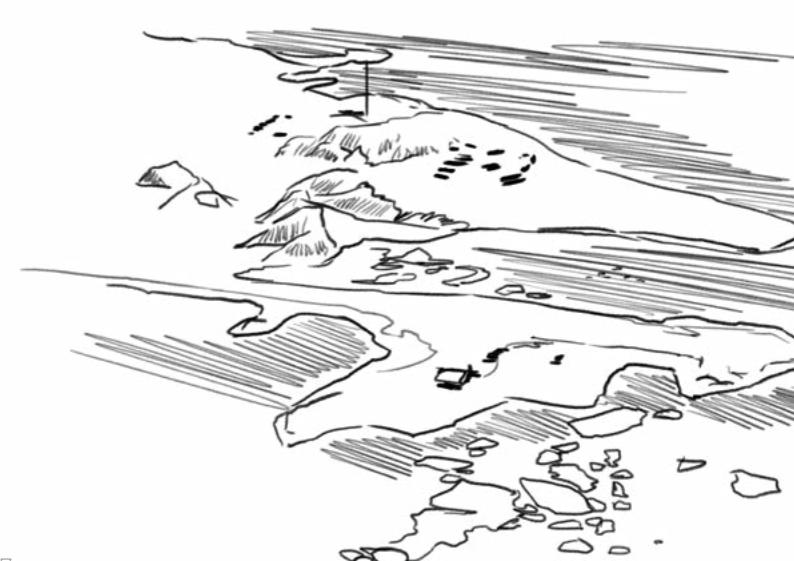
The main objective of the «SEISMOLOGY/OBS» program is the continuous, broad-band, high-resolution observation of ground motion, especially in the generally under-sampled high latitudes of the southern hemisphere. Recorded and quality controlled data are freely distributed to the international scientific community both in real- and delayed-time. Our data contribute equally to global and southern-hemisphere tomographic studies, to seismicity studies, and to studies of microseismic noise. Our goals are to maintain or improve the quality of the data, to improve the robustness of the data recording and distribution procedures, and to increase their national and international utilization.



Concordia, Terre Adélie, Amsterdam,
Crozet, Kerguelen, St Paul
ANTARCTIC, SUBANTARCTIC



Zigone Dimitri



139

GEOMAGNETISM/OBS

BCMT-EOST: THE FIVE FRENCH MAGNETIC OBSERVATORIES IN AUSTRAL TERRITORIES AND ANTARCTICA

The 5 permanent magnetic observatories (Amsterdam, Crozet, DômeC/Concordia, Dumont d'Urville and Kerguelen) are located in remote and isolated locations. They are therefore of great significance for the observation of the internal magnetic field but also for the study of phenomena generated by the solar wind at the surface of the globe (geoeffectivity). These 5 observatories meet the highest international standards and norms thanks to the development of specific procedures and acquisition chains. The Earth's magnetic field is recorded continuously with sampling rates of 1 second. Absolute manual measurements of the magnetic field components are also made daily throughout the year. Data processing and dissemination at the Central Terrestrial Magnetism Office (Bureau Central de Magnétisme Terrestre SNO-BCMT) and at world geophysical data centres (WDC for geomagnetism - World Data Centers, INTERMAGNET) are carried out every 12 hours UT thanks to the acquisition system integrating expedition protocols. The continuity, quality, stability and homogeneity of these observations are of prime importance for their continuous use by the both Solid Earth and Astronomy-Astrophysics scientific communities. Our goals are to maintain or improve the quality of the data, to improve the robustness of the data recording and distribution procedures, and to increase their national and international utilization.

209

NDACC ANTARCTICA

LONG-TERM UTLS AND STRATOSPHERIC OZONE MONITORING, STRATOSPHERE-CLIMATE INTERACTIONS: NDACC-FRANCE ANTARCTIC CONTRIBUTION

The objectives of the 209 program "NDACC Antarctic" consist in long term monitoring associated to process and climatological studies on both the particle population (aerosols, cirrus, Polar Stratospheric Clouds - PSC) and chemical composition (including stratospheric ozone) of the Upper Troposphere / Lower Stratosphere. The global thematic is the stratospheric ozone chemistry and depletion, in a changing climate context. Consequences on UV-B radiation on ground, as well as ozone interactions with climate, especially concerning the impact of green house gases increases are also investigated. A set of instruments dedicated to the measurements of clouds occurrence and physical characterization, and ozone, along with the parameters involved in its chemical equilibrium is currently implemented on the French stations Dumont d'Urville and Kerguelen. These instruments are: UV-Visible spectrometers, UV-B broad-band detector, balloon ozone soundings and lidar (Rayleigh/Mie/Raman). The observed variables are ozone, total column and vertical profiles, aerosols and PSC profiles, temperature, nitrogen dioxide and erythemal UV-B. This observatory program is part, at the French level, of the Observing Service NDACC-France.

227

RAYCO

OBSERVATION OF THE NUCLEONIC COSMIC RAY COMPONENT

Continuous observation of the nucleonic cosmic ray component:

As the French contribution to the international network of neutron monitors and to the NMDB database

To study relativistic proton acceleration in solar eruptive events, and solar particle events in general

To provide the data for, and to improve the models used by the Sievert system (DGAC-French civil aircraft authority; IRSN - French institute for radio protection and nuclear safety).

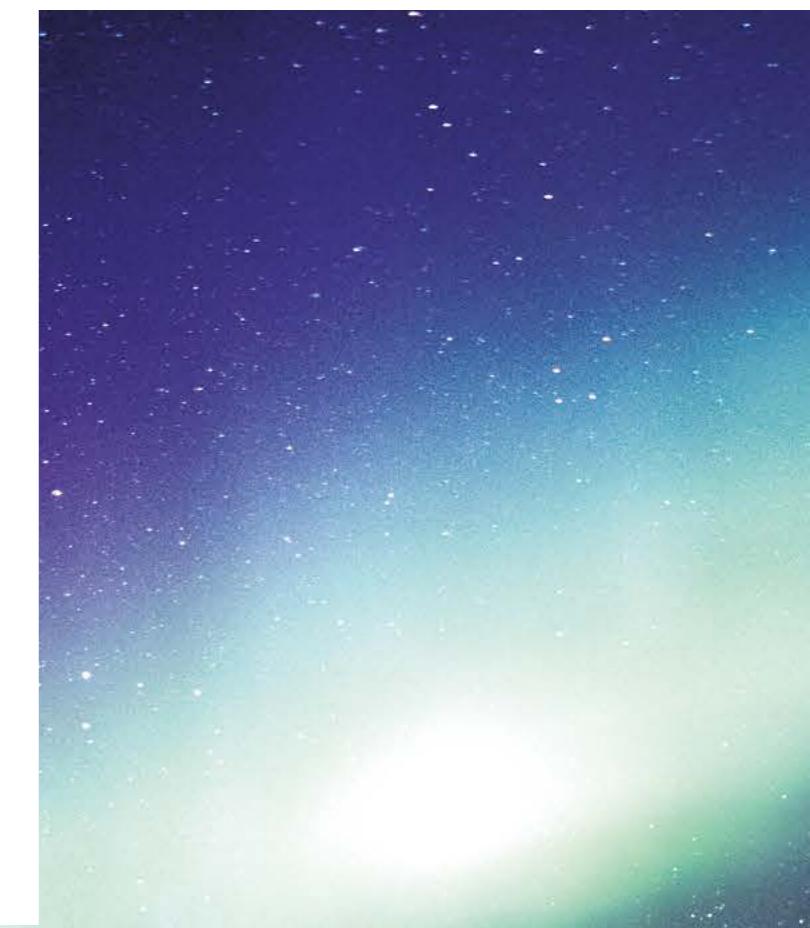


- Terre Adélie, Kerguelen
ANTARCTIC, SUBANTARCTIC
- Klein Karl-Ludwig



Concordia, Terre Adélie, Amsterdam
Crozet, Kerguelen
ANTARCTIC, SUBANTARCTIC

Chambodut Aude



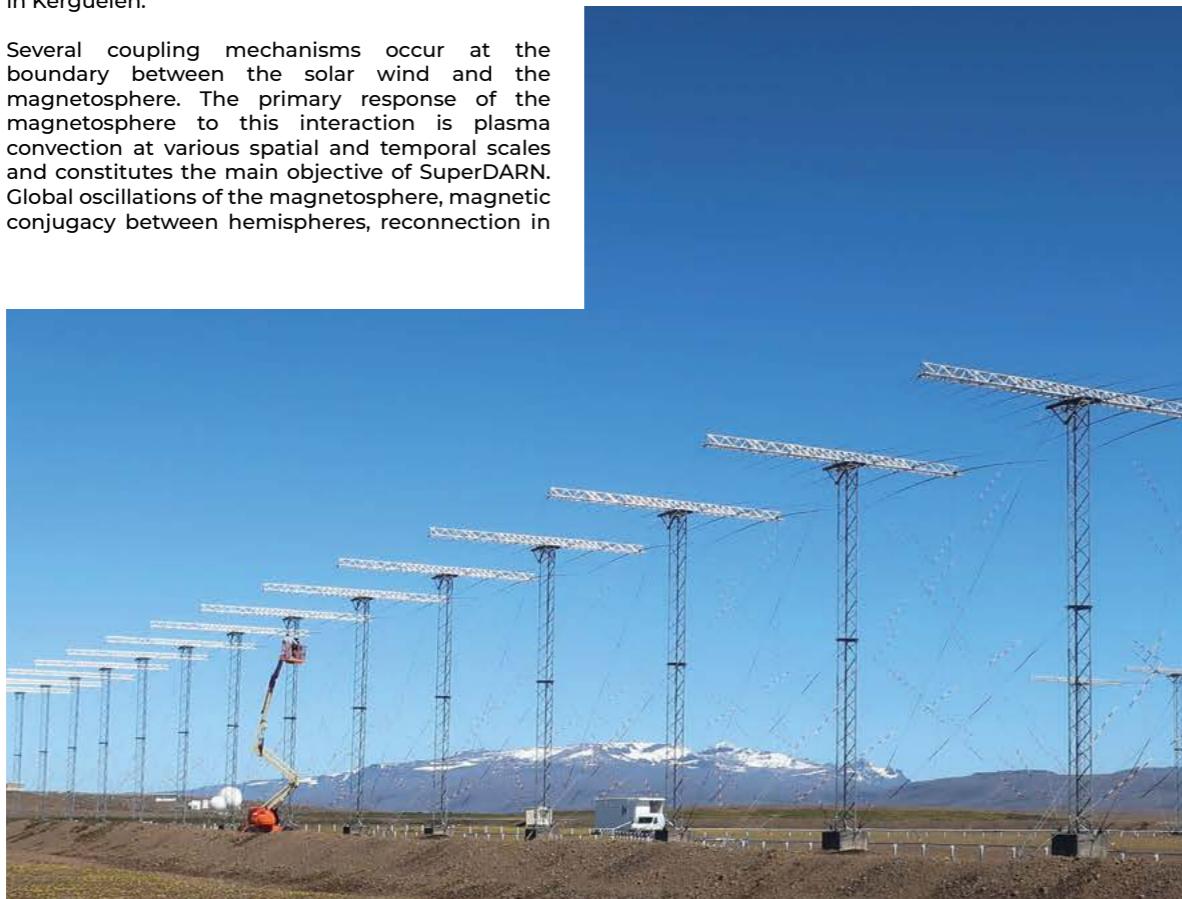
312 SUPERDARN KER

SUPERDARN KERGUELEN

The radial flux of charged particles from the sun called the solar wind is responsible of the existence of a cavity where the Earth's magnetic field is confined, the magnetosphere. Inside the magnetosphere, the dynamics of the ionised gas (plasma) results from the interaction of the solar wind with the magnetosphere at its outer boundary. Because magnetic field lines in plasma are highly conducting, processes occurring at the magnetopause and in the outer magnetosphere map down along the Earth's magnetic field lines, to the high-latitude ionosphere where their signatures can be observed by radars.

At high frequencies (HF), a radar signal transmitted to the ionosphere is refracted and partly backscattered by the small-scale electron density irregularities. The Doppler shift of the backscattered signal is a measure of the radial velocity of the plasma. SuperDARN (Dual Auroral Radar Network) radars can thus monitor the plasma convection over large areas (53° in azimuth and 3500 km in range). In order to determine a velocity vector from two independent components, two radars on different sites share a common field of view. SuperDARN is an international consortium and consists of a total of 35 radars operating in the Northern and Southern hemispheres. The French contribution to SuperDARN consists of the radar in Kerguelen.

Several coupling mechanisms occur at the boundary between the solar wind and the magnetosphere. The primary response of the magnetosphere to this interaction is plasma convection at various spatial and temporal scales and constitutes the main objective of SuperDARN. Global oscillations of the magnetosphere, magnetic conjugacy between hemispheres, reconnection in



411 GLACIOCLIM-SAMBA

THE GLACIERS, AN OBSERVATORY OF CLIMATE, ANTARCTIC COMPONENT

This project is the renewal of GLACIOCLIM SAMBA program, which was initiated in 2004. GLACIOCLIM SAMBA is the Antarctic component of the GLACIOCLIM SNO, in order to detect, monitor and understand climate and mass balance variability and change in the glacial environment. The program proposes surveying and maintaining the surface mass balance networks at Cap Prud'homme (CP, summer and winter surveys), along a 156 km transect (1 survey/yr), and at Concordia (1 survey/year or more) and the meteorological instruments deployed near CP. Special meteorological and glaciological observing periods are also planned in order to analyze particular meteorological processes.



Kerguelen SUBANTARCTIC

Marchaudon Aurélie

Concordia, Terre Adélie ANTARCTIC

Favier Vincent

414 CESOA

ATMOSPHERIC SULFUR CYCLE IN RELATION WITH CLIMATE AT MID AND HIGH SOUTHERN LATITUDES

The atmospheric Sulfur cycle at high southern latitudes: interannual variability of marine biogenic emissions (sea-ice, ocean temperature, oceanic DMS content, chlorophyll a, short-term climatic event such as ENSO) and future response to global climate change. That is based on ongoing year-round studies of sulfur aerosol at DDU



Dumont D'Urville ANTARCTIC

Legrand Michel



416 SNO-AMS / ICOS-FRANCE

GREENHOUSE GASES MONITORING AT AMSTERDAM ISLAND

The goal of the greenhouse gases measurement program at Amsterdam Island is to contribute to long term atmospheric monitoring within the framework of the ICOS-France National Observation Service and the international GAW (Global Atmospheric Watch) network from World Meteorological Organization. Amsterdam Island is a reference site for atmospheric watch (clean site), and measurements conducted in-situ enable us to better estimate the austral ocean impact as a carbon sink and better understand the associated mechanisms. This location is also well suited to trace emission transport coming from South Africa. In addition to continuous CO₂ and CH₄ measurements and weekly flask sampling (CO, H₂, N₂O, CO₂ isotopes) conducted since several years, we propose to set up continuous CO and N₂O measurements and to restart the O₃ monitoring over the next 4 years. The 222-Radon measurements as well as meteorological parameters which enable an accurate air mass origin characterization will be continued. In order to further increase our knowledge about the Austral Ocean carbon sink, we think about setting up a continuous and high precision atmospheric oxygen analyzer.



Crozet, Amsterdam, St Paul, SUBANTARCTIC

Delmotte Marc



665 MINERVE

The MINERVE project (Mesures à l'Interface Eau- air de la Variabilité des Echanges de CO₂), based on oceanographic cruises, aims to observe and understand seasonal variabilities of CO₂ partial pressure (pCO₂), Total Dissolved Inorganic Carbon and Total Alkalinity of surface seawater, in association with hydrological and in-situ biogeochemical measurements, and also using remote sensing data (temperature, seawater color). Logistical routes of the Astrolabe lead to poorly known areas and allow to collect information in order to understand processes involved in the mesoscale spatio-temporal variability of pCO₂ in the austral oceanic regions. Data collected during these cruises will be used as a background to estimate interannual and averaged variability (trends) of the CO₂ net flux through the air/seawater interface. Measurements collected during the MINERVE project will be used also by other colleagues to constrain atmospheric models and validate biogeochemical models coupled with circulation models in order to simulate the carbon cycle for the next decades and centuries.

- Astrolabe**
ANTARCTIC
- TOURATIER Franck**

688 NIVMER

NIVMER

The NIVMER program aims to maintain and develop the ROSAME tide gauges network as part of the SONEL french observatory and in the frame of the international GLOSS program. This program is complementing several research and monitoring, national and international, programmes using in situ sea level observations in the Indian sector of the Southern Ocean (Long term sea level change, tsunami warning system, satellite calibration, ...). This tide gauges network is the french contribution in this part of the ocean to the GLOSS core network.

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- Dumont d'Urville/Cap Denison,
Kerguelen, Amsterdam - Saint-Paul
ANTARCTIC, SUBANTARCTIC
- Testut Laurent**

694

SURVOSTRAL

The main objective of the SURVOSTRAL project is to MONITOR different physical parameters in the AuSTRAL Ocean with long-term hydrological measurements. SURVOSTRAL started in 1992-1993, and since then the ocean heat content in the first 800 m and the surface salinity have been measured regularly on a repeated line (6-10 times a year) between Tasmania and Antarctica. These measurements form the longest time series of seasonal and interannual variations of these parameters in the Southern Ocean, and are therefore a key value for quantifying oceanic changes in this key climate region.

The overall objectives are as follows:

- A monitoring of the seasonal, interannual and decadal variability of the heat content of the Southern Ocean and its response to changes in atmospheric heat fluxes.
- A study of surface salinity and its relationship with the freshwater balance in the Southern Ocean.
- Study of the transport and structure of the Antarctic Circumpolar Current (ACC).
- Study of the variation of the different thermal and haline fronts.
- Study of the role of oceanic eddies in the flow of mass, heat and salt through the CCA.

The SURVOSTRAL project uses the regular rotations of the supply vessel ASTROLABE between Hobart and Terre Adélie. This transit enhancement project is based on high spatial resolution XBT and thermosalinograph measurements. Participating in this project supported by IPEV: LEGOS (France), CSIRO (Australia) and the Scripps Institution of Oceanography (USA). SURVOSTRAL is currently integrated into CLIVAR and the scientific valorisation is financed by TOSCA (CNES).

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- Astrolabe**
ANTARCTIC
- MORROW Rosemary**





910

HAMSTRAD

H₂O ANTARCTICA MICROWAVE STRATOSPHERIC AND TROPOSPHERIC RADIOMETERS

The HAMSTRAD radiometer is a genuine state-of-the-art microwave instrument dedicated for the detection of 1) the 60-GHz oxygen line to measure tropospheric temperature profile, and 2) the 183-GHz water vapour line to get tropospheric H₂O (profile and precipitable water). It has been installed at Dome C in 2009 and is running normally since 2010. The initial aim of the HAMSTRAD project was to measure the trends in water vapour and temperature profiles from the lower part of the troposphere to the lower part of the stratosphere and their links with climate change. Coupled with other instruments operating at Dome C (e.g. aerosol Lidar), the HAMSTRAD project also intends to study the genesis of thick clouds and diamond dust (ice particles) above the Dome C station by using the information coming from measurements (in situ and remote sensing at the station, satellites) and meteorological analyses of different parameters: temperature, water vapour, ice, precipitation, AOD, radiation, particles, etc. To date, the project has produced 12 peer-reviewed papers.

910

Concordia
ANTARCTIC

Ricaud Philippe



1013

CALVA

IN SITU DATA FOR THE CALIBRATION AND VALIDATION OF METEOROLOGICAL AND CLIMATE MODELS AND SATELLITE REMOTE SENSING, FROM THE COAST OF ADÉLIE LAND TO DOME C.

The aim of CALVA is to gather series of in situ observations in Adélie Land and at the Dome C, which are needed to better evaluate and improve Antarctic meteorological models and global climate models over Antarctica. The observations also aim to contribute to improve remote sensing methods. In Adélie Land, CALVA focuses on precipitation, extreme dynamic atmospheric boundary layer (catabatic winds) and drifting and blowing snow. At Dome C, CALVA also focuses on precipitation and clouds, and on the boundary layer, which is extreme here in terms of temperature and inversions and exchange fluxes with the snow surface. These are poorly known aspects of the Antarctic meteorology and climate, which are consequently poorly represented or simply ignored (blowing snow) in the models used for IPCC climate change predictions. The observations thus aim to improve those predictions, in particular those of the surface mass balance of the ice sheet and impact on sea-level.

1013

Dumont d'Urville,
Concordia
ANTARCTIC

Genthon Christophe



1028

GMOSTRAL 3

OBSERVATIONS MONDIALES SUR LE MERCURE : SURVEILLANCE DE L'ATMOSPHÈRE ET ÉTUDES DES PROCESSUS ATMOSPHERIQUES DANS LES RÉGIONS SUBANTARCTIQUES ET LES TERRES ANTARCTIQUES

Mercury (Hg) is a potent neurotoxin that is globally dispersed in the atmosphere. Humans are mostly exposed to mercury by eating seafood. In 2017, the Minamata Convention has come into force, which aims to limit the use, emissions and health impacts of mercury globally. The Convention's effectiveness in lowering

Mercury emissions

Environmental concentrations of mercury and ultimately

Une meilleure paramétrisation des voies human exposure to mercury will have to be evaluated.

How does the scientific community can contribute to assess the effectiveness of the convention and the government policies ?

GMOSTRAL-3 proposes to work at improving process knowledge and decision tools such as models through:

A continuous survey of atmospheric mercury (since 2012) at key sites of the Southern Hemisphere (Concordia Station and Amsterdam Island)

The development of alternative strategies to monitor Hg (and other contaminants) at lower cost

A better parameterization of oxidation pathways of Hg using innovative approach (Hg isotopes, oxidized Hg speciation)

Coordinated campaigns on atmospheric oxidants (as halogens)

1028

Concordia, Amsterdam
ANTARCTIC, SUBANTARCTIC

Magand Olivier

1053 DACOTA

DYNAMICS OF COASTAL OUTLET GLACIERS AND IMPLICATIONS ON THE OVERALL MASS BALANCE OF THE EAST ANTARCTIC ICE SHEET

The Astrolabe glacier serves as a test zone for measuring and understanding the dynamics of East Antarctic outlet glaciers. It is part of the more general observatory CRYOBS-CLIM (<https://cryobsclim.osug.fr/>) which aims at understanding the links between the environment (essentially climate forcing) and resulting glacier changes. These links operate at two principal levels:

Climate changes induce surface mass balance changes which indirectly impact the environment

Surface mass balance changes constitute the principal boundary conditions in the dynamic evolution of ice masses

If the first aspect is principally covered by the GLACIOCLIM Observatory (IPEV program 411), the aim of the present proposal is to tackle these ice dynamics mainly driven by surface mass balance changes and, to a lesser degree, by direct climatic inputs (essentially temperature) and as such, appears fully complementary to the GLACIOCLIM one. Since the ice discharge in Antarctica is by more than 80 % drained by outlet glaciers from the eastern ice sheet, understanding their dynamics and being able to model their present and future behaviour is crucial when addressing the sea level issue. The proposed approach is double by first proposing a comprehensive survey of the selected test glacier in order to capture the specific dynamics of marine outlet glaciers and feed relevant ice flow models.

Corresponding results will then in a second time be applied to the modeling of the large outlet glaciers of the Wilkes-Terre Adelie land sector of east Antarctica whose contribution to sea level is major and needs to be constrained. The core of the activities detailed in the proposed program concerns the first task implying field work on the Astrolabe glacier. As for the second part, it is carried out through an international collaboration of our program with the University of Texas under the form of several airborne geophysical campaigns. These measurements allow for assessing the environment settings of these large glaciers (bedrock and surface topographies, outlining of respective grounded and floating parts.) necessary for conducting the modeling of their future behaviour.



Terre Adélie
ANTARCTIC



Le Meur Emmanuel

1066 ASTEP+

ASTEP+ : ANTARCTIC SOUTHERN PHOTOMETRY TELESCOPE

Exoplanets are now discovered on a daily basis thanks to many astronomical surveys. These surveys require additional follow-up observations for validation or for joint observations at different wavelengths. This need will become even more important with the launch of TESS and JWST. In this domain, the potential of robotic medium size (30-80 cm) telescopes has been demonstrated by TRAPPIST in Chile with its successful confirmation and characterization of more than 90 exoplanetary systems. In parallel, recent results obtained on the characterization of the delta Scuti oscillations of beta Pictoris, with ASTEP-400, a photometric 40cm telescope, have demonstrated that a very accurate photometry can be obtained with an automated telescope operated from the Concordia station with minimal human interventions. We propose to continue operating ASTEP in 2019 and beyond. The core of the ASTEP+ project requires only maintenance work to keep the mount, telescope and support system operational and limit the failures during the year. Minor adjustments are proposed to improve the image resolution and for a more complete remote control of the instrument. ASTEP+ will be operated in coordination with TRAPPIST. It will observe stars with exoplanets detected in radial velocity to check for possible planetary transits, confirmed transiting planetary systems to characterize them, and generally any target of opportunity that is of high scientific interest. ASTEP+ will also follow up the southern hemisphere planet candidates to be discovered by NASA/TESS space mission.



Concordia
ANTARCTIC



Guillot Tristan

1077 TALISKER

FLUIDS AND MAGMAS TRANSFERS ACROSS THE LITHOSPHERE OF KERGUELEN

Kerguelen corresponds to a unique geodynamic context and geological history, with no current equivalent on Earth, a contemporary analogue of the formation of the first continents 4 billion years ago. The study of the productions, the migrations and the emplacement of differentiated magmas in an oceanic context, the characterization of alteration processes (serpentization) and mantle fertilization, the distinction in the micro-tectonics between local magmatic causes and regional incidences of the oceanic plate dynamic as well as the geometry of the different parts of the lithosphere and fluids circulations between them allow to provide constraints to clarify the current geodynamics and the scenario of the formation of the first continents on Earth. The current geographical situation is also strategic to constrain the climatic evolution of the last millions of years by studying the dynamics of erosion of the rocks of the archipelago and matter transfers towards the ocean.



Kerguelen
SUBANTARCTIC



Guillaume Damien



1094 PALAS2

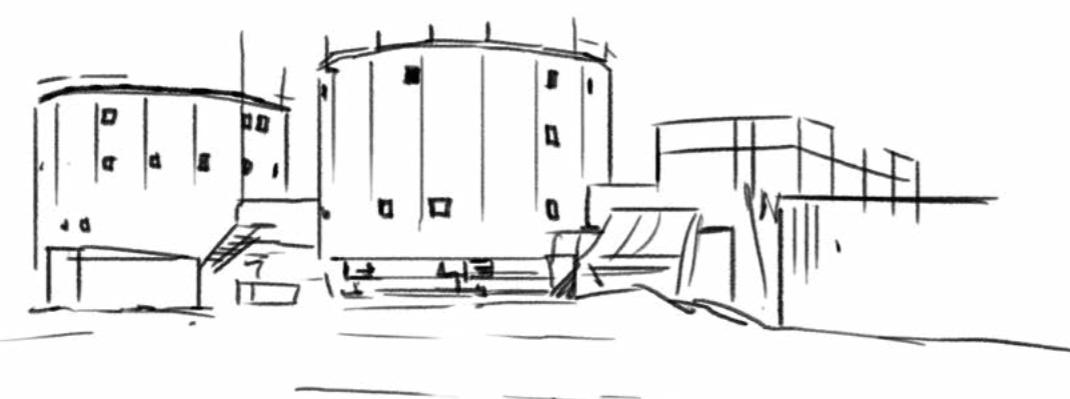
PALEOCLIMATE FROM LAKE SEDIMENTS ON KERGUELEN ARCHIPELAGO 2

This project is a joint proposal of EDYTEM (CNRS, université Savoie Mont Blanc) and the Department of Earth science, University of Bergen. The objective of this project is to perform at least Holocene-long sediment cores from Kerguelen lakes in order to do high resolution continuous reconstructing of past climate fluctuations with sedimentological and geochemical proxies. The proposal is connected to an ongoing project at University of Bergen where similar sites in Northern Hemisphere will be investigated with the same methods together with sites at South Georgia in the southern Atlantic Ocean. In this proposal focused on Kerguelen Archipelago, two complementary approaches will be applied:

In Lake Armor, a lake with no glacier in its catchment area, erosion fluxes will be used to reconstruct past precipitation patterns (already cored in 2014, under study)

In lakes with a glacier in their catchment area (Lake Guyemer area and Lake Aphrodite area), erosion fluxes will be used to reconstruct past glacier fluctuations (this proposal)

In a second time, this two records will be associated to reconstruct the past shift or changes in intensity of the Southern Westerly Wind. Finally, those approaches will be completed by Holocene sea-salt aerosols reconstructions from element geochemistry.



Kerguelen
SUBANTARCTIC

Sabatier Pierre

1110 NIVO

SNOW PROPERTIES EVOLUTION IN A CHANGING CLIMATE IN ANTARCTICA

The NIVO program is interested in the evolution of snow at and near the surface from time scales of hours to a few years. The aim is to understand the role of snow in the climate. The snow surface exchanges momentum, energy, water vapor (for different isotopes) with the atmosphere which gives rise to numerous feedback loops involving many processes (radiative, aerodynamic, turbulent, ...). To understand and parametrize these processes and feedbacks in snow and climate models, NIVO operates a set of automated instruments and collect manual measurements in order to characterize snow in the shallow subsurface and in depth up to tens of meters. The goal of the next four years is to investigate inter-annual variations of grain size, density, albedo, temperature and the isotopic composition, to understand the evolution of the surface roughness, to advance on the exchange of vapor for stable water isotopes, and to progress on metamorphism laws at low temperature. NIVO also aims at providing essential data on snow microstructure and ice electromagnetic properties for the calibration/validation of satellite data which in turn helps to generalize the findings from Dome C to the whole Antarctic continent.



Concordia
ANTARCTIC



PICARD Ghislain



1112

CHINSTRAP

CONTINUOUS HIGH-ALTITUDE INVESTIGATION OF NEUTRON SPECTRA FOR TERRESTRIAL RADIATION ANTARCTIC PROJECT

The CHINSTRAP project aims at installing a high-energy extended neutron spectrometer at the Concordia station in Antarctic. The particularities of this location are unique (high altitude and proximity to the geomagnetic pole) and allow long-term measurements dedicated to the study of the atmospheric natural radiative environment dynamics for Space Weather applications. These data will complete the ones already obtained at the Pic-du-Midi in France and in the Pico dos Dias in Brazil, near the South Atlantic Anomaly. The project includes two phases: the first consists in installing and operating the HERMEIS in the station; the second consists in investigating the data then in combining their analyses to those from other measurement sites.



Concordia
ANTARCTIC



Hubert Guillaume

1165

AERONET

AEROSOL MONITORING USING SUN PHOTOMETER AT AMSTERDAM ISLAND (AERONET/PHOTONS STATION)

This project aims to maintain the AERONET measurements at Amsterdam Island. These measurements provide optical and microphysical properties of aerosols in the atmospheric column. Very few «clean marine» stations are currently in operation in the AERONET network. Observations initiated since 2002 at Amsterdam Island thus represent an important component of AERONET and will continue in this new IPEV project. Most of the work on site concerns for the installation (once / year) and monitoring (maintenance, data) of the measurements provided by a sunphotometer CIMEL. Data is shared and publicly accessible in near real time in the AERONET database. This project was previously managed by the IPEV program AEROTRACE (415) led by Jean Sciare (LSCE).



Amsterdam
SUBANTARCTIC



Goloub Philippe

1169 EAIIST

EAST ANTARCTIC INTERNATIONAL
ICE SHEET TRAVERSE

Italian, French and US scientists unite their knowledge and capability to study the interior of the Antarctic plateau between the French-Italian Concordia station (75° S, 123° E), and the US South Pole station (90° S). The scientific objectives of EAIIST are to study the icy terrain of the Antarctic continent in its driest places. These areas are largely unexplored and unknowns and offer unique and extraordinary morphological characteristics: presence of mega-dunes, glazed ice surface, and thermal cracks, structure probable analog to glacial age on deep drilling sites such as Dome C or Vostok. A consortium of scientists from three nations, Italy, France and US is built around the idea to explore and study the geophysical (snow physics, surface mass balance, density, temperature, seismicity, etc.), geochemical (impurities, aerosols, air-snow transfer, water isotopes, etc.) and meteorological dimensions (AWS, atmospheric dynamic, air mass transport, etc.) of these most inhospitable, remote and unknowns regions of the planet by the means of a scientific traverse.



1177 CAPOXI 35-75

CAPACITÉ OXYDANTE
DE L'ATMOSPHÈRE 35-75 °S

The CAPOXI 35-75 project aims to document the oxidative capacity of the southern hemisphere following a North-South latitudinal gradient, from the Amsterdam Island (37° S) to the Concordia station (75° S), including the Dumont d'Urville coast station (67° S). The program will specifically be dedicated to solve few inconsistencies observed these past few years in Antarctica. If the high oxidative capacity of the Antarctic plateau atmosphere is a well established phenomena, induced by the snow emission of nitrogen oxides, it is however difficult to reconcile our current knowledge of the oxidation schemes with the ground observations. Such discrepancies strongly limit our capacity to understand to ice core records. In this program, we propose to revise some of the key parameters governing of the oxidation state of the atmosphere. By managing scientific stations from 37 to 75° C, IPEV offers the unique opportunity to study the oxidative capacity in very contrasting environments that will ease to reveal the different interaction between reactive species. The project will focus on the nitrogen oxides and halogen species in direct link with the ozone budget and will benefit from international collaboration to access specific instrumentation and modeling tools not available in our group.



1184 BINGO

BIOAVAILABILITY OF IRON
CONTAINED IN NANOPARTICLES
OF GLACIAL ORIGIN

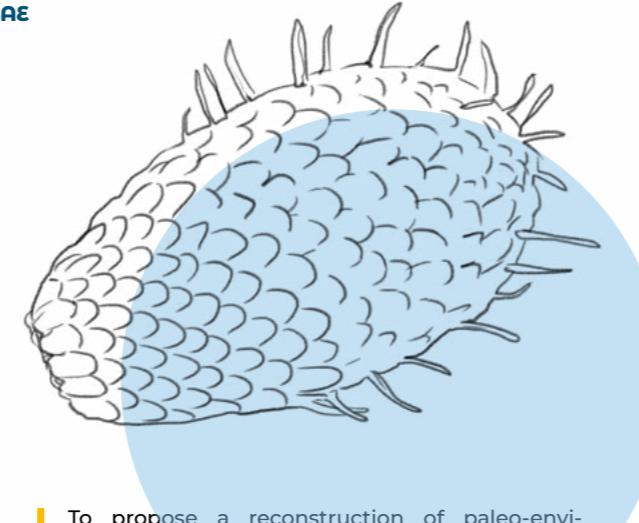
The southern Ocean is a key player for the control of atmospheric CO₂ and therefore climate. However the biological pump of CO₂ in this ocean is severely limited by the availability of iron for phytoplankton. But a few oasis exist where enhanced biological activity results from natural iron fertilization. These regions are excellent natural laboratories and the Plateau of Kerguelen and the waters extending eastward are a good example. BINGO aims to investigate a so far unexplored issue in this region: the role of glacier melting as iron source for the ocean. BINGO proposes a study focused on the Cook Ice Cap. The challenge will be to detect iron nanoparticles in the melting water of the glacier and to evaluate their bioavailability for phytoplankton. BINGO relies on an expedition at Kerguelen where we will first collect the particles in the vicinity of the Glacier Ampère and second we will test the availability of these particles for iron limited phytoplankton at Port aux Français. Investigation conducted both from a geochemical and biological perspectives will provide original results that will contribute to better understand the future of Southern Ocean considering accelerated melting of ice caps.



1200

ENVIKER

CHARACTERIZATION AND MONITORING OF ENVIRONMENTS AND PALEOENVIRONMENTS FROM KERGUELEN USING TESTATE AMOEBAE



Due to their geographical position, under the influence of the Southern Hemisphere westerly winds and under the influence of the Antarctic Circumpolar Current, Kerguelen archipelago, in the sub-Antarctic, is a perfect natural experimentation site for the record of recent environmental change.

The testate amoebae have been studied in Antarctica and the subantarctica islands through about a hundred studies. In the islands of Kerguelen, they are described in four rather extensive studies in 1904, 1908, 1912 and 1981. These studies reveal the presence of cosmopolitan species with a few rare or a more restricted distribution. The proportions of the different species and the composition of the communities depend on the hygrometric degree, the pH, the temperature and the biogeographical factors. On the other hand, the skeletons of these amoebae are preserved and are therefore witnesses of past environments. Thus, by characterizing the environmental constraints of testate amoeba communities within modern environment and by defining indicator species of all identifiable sub-environments, it is possible to reconstruct recent paleoenvironments and model the important changes operating in recent decades.

Thus, the long-term project consists of setting up a tool for characterizing the environmental changes recorded in the subantarctic islands based on observation of preserved testate amoeba. The objectives of the EnviKer program are:

To propose a denser and more exhaustive cartography of the amoeba communities in the different Kerguelen island landscape units following distincts gradients: a East-West precipitation gradient, a gradient of quality and quantity of the organic/inorganic substrate and a gradient of hydrolysis as revealed by clay minerals. The project will focus particularly on mineralogy and molecular geochemistry to precisely define the characteristics of the environment. The diversity of testate amoebae will be estimated by both genetic techniques and more classical observations. For each environmental unit, we will define the indicator species. The different interactions are summarized in the figure within the general objectives paragraph.

To propose a reconstruction of paleo-environments based on the statistical analysis of testate amoebae indicator species, extracted from sediment cores. In lacustrine environments the studied cores are those recovered by the projects PROTEKER and PALAS managed by the EDYTEM Laboratory under the direction of Fabien Arnaud. Since these cores benefit from numerous analyzes from the point of view of organic, molecular and inorganic chemistry, we will benefit from an efficient database for the comparison of the paleoenvironments that we will reconstitute with the testate amoebae. We will complete the sampling with short cores in the peat bogs, soils and plants in pillows in which we will deploy all possible analyzes.



Kerguelen
SUBANTARCTIC



Armynot du Châtelet Éric

1202

BE-OI

BEYOND EPICA: OLDEST ICE (RECONNAISSANCE PHASE)

BE-OI is a H2020 European project (Coordination and Support Action, IPEV, PNRA and CNRS being official contractors) to locate in Antarctica optimal sites where a deep drilling operation could be conducted during the decade 2020. The aim is to recover a stratigraphically-ordered sequence of climate and atmospheric/environmental conditions going back to 1.5 million years before present, overlapping the so-called mid-Pleistocene transition when the pacing of glacial-interglacial cycles dramatically changed from 40 to 100 kyr periodicities. Ultimately, the main question lies in the role played by greenhouse gases in this major change.

On the French and Italian side, the focus reconnaissance work of BE-OI takes place at Concordia and its vicinity. In 2016/2017, the site of «Little Dome C», located about 40 km west from Concordia along the ridge toward Vostok station, has seen extensive radar survey, a first series of phase radar measurements, GPS positioning as well as a first test drilling with the British RAID rapid access drill. At Concordia itself, the first test campaign of the highly innovative SUBGLACIOR reconnaissance probe was conducted. 2017/2018 will see a second test season for SUBGLACIOR (if logistics permits it), a second deployment of RAID, as well as GPS and phase radar measurements.

The BE-OI component presented here covers the follow-up of the 2018/2019 and 2019/2020 field seasons: the SUBGLACIOR deployment at the optimal site of Little Dome C, a site defined during the field season 2017/2018, as well as additional deformation measurements and the first field deployment of the Swiss rapid access tool RADIX. 2019/2020 will either see a reiteration of the above activities, or the start of camp buildup anticipated for the following deep drilling operation. In addition, tests of new logging tools (notably a sonic logger) in the EPICA borehole are anticipated during these two seasons, before their deployment in the BE-OI reconnaissance boreholes.

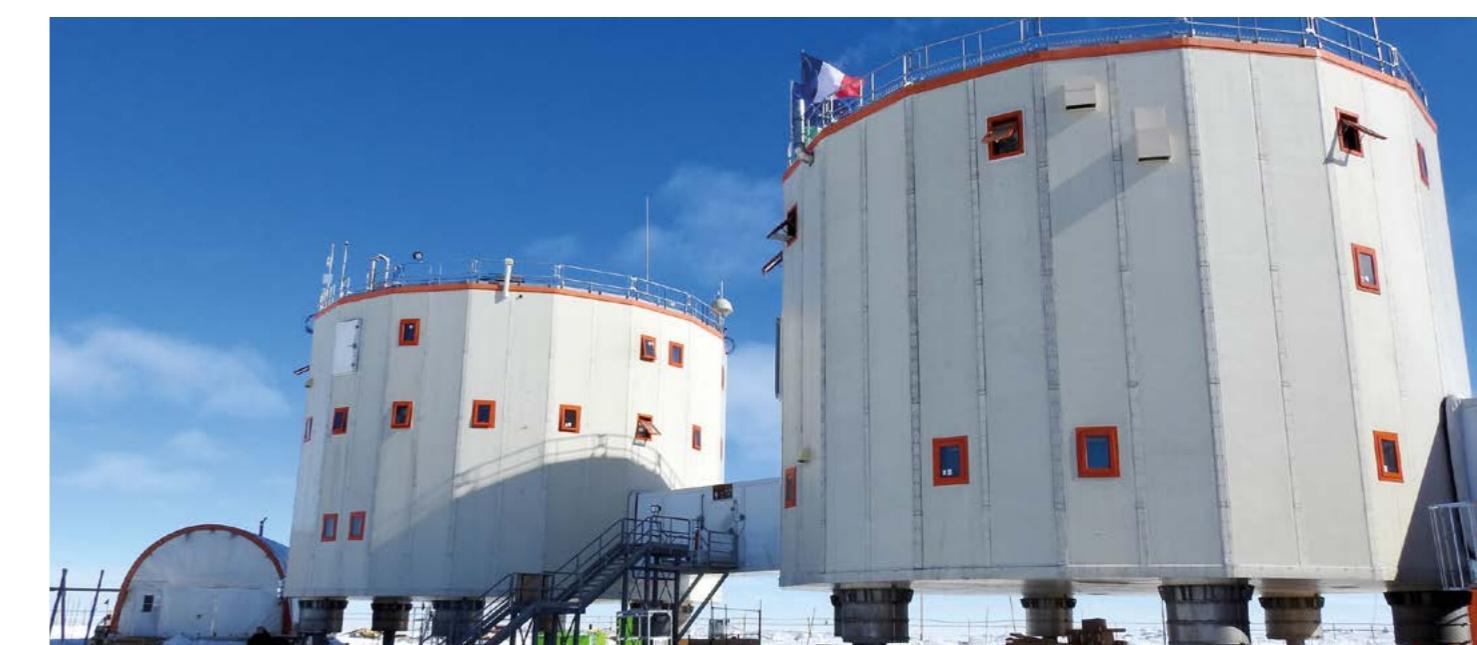
The IPEV project BE-OI therefore represents most of the French and Italian declination (+ part of the Swiss contribution) of the European project BE-OI. For the field seasons 2016/2017 and 2017/2018, the latter was incorporated into two projects: SUBGLACIOR-1119 and part of GLACIOLOGIE-CONCORDIA-902. At the request of IPEV and for ease of follow-up by the CPST, the following two field seasons see the merging of these two projects (in part for 902) into a single one, named BE-OI.



Concordia
ANTARCTIC



Alemany Olivier





1203

ARCHIVE EPICA

MANAGEMENT OF THE EPICA-DC
ICE CORE STORED AT CONCORDIA

The EPICA ice core, drilled at Dome C is 3260 m long and allows to record climatic changes over the last 800,000 years. It is therefore a particularly valuable archive. A quarter of the ice core (over the entire length) has been kept in an ice cave dug into the snow, where the average annual temperature is -55°C. The reason for this on-site storage is indeed to keep the ice at very low temperatures as required by certain measures. The rest of the ice core was either distributed to EPICA's various partners or kept in cold rooms at -25°C, near Grenoble. The objective of this project concerns the management of the archive remaining in Concordia. The tasks are:

- Respond to sampling requests from various national or international groups (once endorsed by EPICA's Steering Committee)
- Finish the repacking of the bags (if it is not finished in 2017-2018)
- Prepare the specifications for the future EPICA cave, taking into account the interactions with the «ice memory»storage project.

This project is thus a service to the ice core community more than a scientific proposal by itself.



Concordia
ANTARCTIC



Teste Gregory

1205

ADELISE

BETTER CONSTRAIN THE ORIGIN OF SURFACE ACCUMULATION AND RECENT CLIMATE CHANGE IN THE ADÉLIE EARTH VIA THE SUPPLY OF WATER ISOTOPES (ADELISE)

Quantification of fluxes of snow and water vapor at the Antarctic surface as well as links with climatic variations is a major challenge for projections of climate and water cycle organization in this region. Still, large uncertainties prevent such quantification. On the one hand, precipitation amount is difficult to estimate because of the influence of wind, a process particularly important on the coastal areas because of the strong katabatic winds. On the other hand, it is particularly difficult to quantify the direct snow exchanges with atmosphere (sublimation / condensation) because of badly constrained processes within the boundary layer (blowing snow, supersaturation, turbulence influence, ...). Finally, climatic variations over the last decades to centuries are often bad documented because of a lack of instrumentation in this region. Water isotopic measurements on shallow ice or snow cores in Antarctica is currently one of the best tools to reconstruct the climatic variability (temperature, accumulation) in the absence of weather station instrumentation. Indeed, because of isotopic distillation from low to high latitudes, it is possible to link temperature to the snow isotopic composition at the seasonal and interannual scale. However, the snow isotopic composition is also sensitive to other effects during snow formation and deposition (e.g. kinetic fractionation, re-evaporation of falling or blowing snow) and after deposition (diffusion, sublimation and hoar deposition). These effects increase the complexity for direct interpretation of snow isotopic composition in term of temperature but also permit to retrieve other information on the snow deposition conditions and water fluxes at the ice sheet surface. Within the ADELISE project, we propose to perform continuous isotopic measurements on the water vapor, precipitation, blowing snow and surface snow at Dumont d'Urville over 2 consecutive years. The isotopic measurements will complement the measurements performed on the LIDAR,

RADAR and pluviometers already in place at this station in order to characterize water cycle processes in the atmospheric column and at the snow surface. The isotopic measurements will be combined with long-term chemistry measurements on aerosol filters within the CESOA program (and following program from 2020) and will permit to better interpret the isotopic and chemistry records obtained on shallow cores drilled recently in Adélie Land within the ASUMA project. Finally, a parallel system of continuous measurements of water vapor isotopic composition will be installed over the same period at Dome C within the NIVO2 project. Combination of the two records with back-trajectories will permit to better understand the isotopic transfer function between the coast and East Antarctica hence improving our interpretation of water isotopes in the Dome C deep ice core.

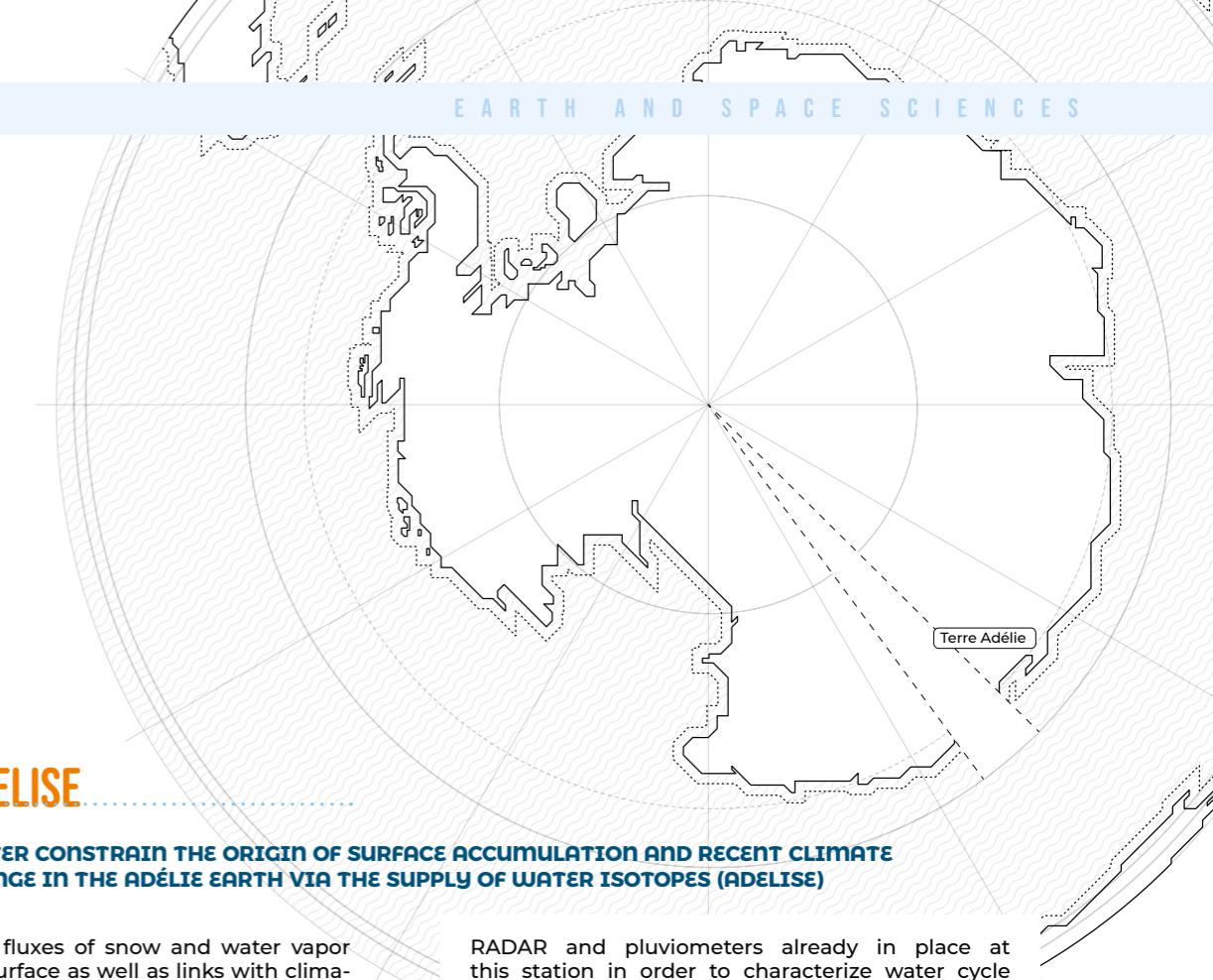
This project also includes a significant part of modeling through the atmospheric regional model MAR already largely applied for Adélie Land. MAR is also currently being equipped with water isotopes. This project will thus permit the validation of the MARiso model as well as its use for interpretation of shallow ice cores recently drilled in Adélie Land.



Terre Adélie, Autre
ANTARCTIC



Landais Amäelle



HUMAN BIOLOGY

1170 ERISI

STUDY ON THE EVOLUTION OF INDIVIDUALS' RELATION WITH THEIR CLOSE SPACIALITY, WITH A STRONG FOCUS ON SENSORY PERCEPTIONS, BEFORE-DURING-AT THE END OF A STAY IN EXTREME AND UNUSUAL AND/OR ISOLATED AND CONFINED ENVIRONMENT FROM THE PERSPECTIVE OF A TAKE INT

The sensory perception assessment protocol ERISI, Year 2 – known as « Per-Sens » part, aims to study the possible sensory perception changes that might experiment individuals during long stay/missions in extreme & unusual environments (EUE - eg. [sub] antarctic stations – up to 14 months in the field) or isolated & confined environments (ICE - eg. Submarines SSBN – board from 70 to 90 days).

If, literature indicates that sense, considered independently of each other, might be modified by such experiences, no holistic research has yet measured what is the very impact of a long stay/mission in EUE/ICE on the sensory perception of individuals and, consequently, the impact of possible changes of perception on their mood, stress level and/or performance.

This study will focus on the evaluation of (1) visual, (2) olfactory, (3) gustatory, (4) tactile, (5) auditory individuals' perceptions and (6) proprioception and body scheme, on an triple investigative pattern "at the beginning", "during" "at the end" of the stay/mission in ICE/EUE.



Dumont D'Urville, Kerguelen,
Amsterdam, Crozet
ANTARCTIC, SUBANTARCTIC



Trousselard Marion



1219

ANTARCV

ALTERATIONS IN TOTAL RED BLOOD CELL VOLUME AND PLASMA VOLUME DURING A ONE-YEAR CONFINEMENT IN ANTARCTICA: EFFECT OF HYPOXIA

Introduction: Short-duration space flight induces circulatory blood volume alterations known as "space flight anemia" and characterized by decreases in red blood cell volume (RCV) and plasma volume (PV). Such hematological alterations may persist during long-duration space missions, potentially impacting the astronauts' health, however this aspect remains unexplored. On the other hand, during long-duration space missions the use of hypoxia is envisaged for technical reasons, but the safety of hypoxia must be first verified since this environmental condition provokes numerous physiological alterations in humans, in particular blood volume changes potentially interacting with the hematological effects induced by space flight . **Objective:** Using Antarctic confinement as a high fidelity Earth-based analogue for long duration deep space missions, we hypothesize that:

Confinement at sea level reduces blood volume by concomitantly decreasing RCV and PV

Chronic hypoxia counterbalances the decrease in RCV but exacerbates the decrease in PV induced by confinement.

Methods:

Using an innovative, automated carbon-monoxide rebreathing technique usable by the wintering staff, blood volumes will be repeatedly measured in two groups of subjects overwintering at Dumont d'Urville (DDU) (sea level group) or Concordia (3200m, altitude group).

1220

SLEEPCOUNT

SLEEP AND NEUROCOGNITIVE DISTURBANCES: COUNTERMEASURES AND INNOVATIVE INVESTIGATION TOOLS UNDER POLAR EXTREME CONDITIONS IN ANTARCTICA

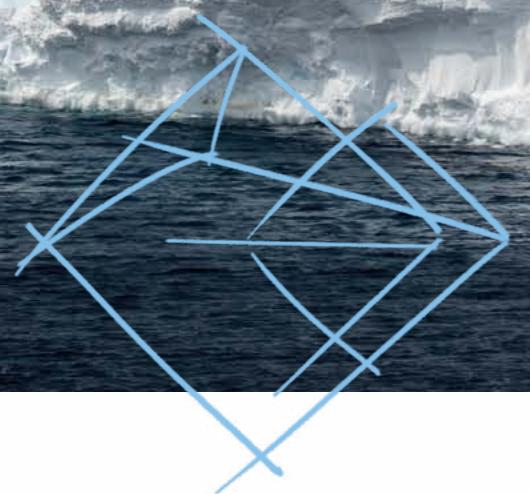
Alterations in sleep quality and quantity have been reported in Antarctica. The main sleep alterations consist of increased sleep onset latency, sleep fragmentation and reduction of slow wave sleep. Circadian desynchronization associated with specific light exposure, isolation and confinement and in some stations, altitude hypobaric hypoxia exposure, are thought to be the main factors associated with sleep disturbances in Antarctica stations. Sleep perturbations and circadian rhythms desynchronization may induce serious cardiovascular, cognitive, emotional and social impairments leading to altered health, safety and mission success of the crew. Countermeasures improving sleep quality remain then of major interest during Antarctica missions as well as for orbital and planetary space missions, since both environments share several factors responsible for sleep disturbances. Compact and user-friendly equipment is also required to monitor sleep over multiple nights whilst maximising compliance compared to standard polysomnography. This project aims first to quantify the effect of sleep disturbances on psychocognitive functions and chronobiological desynchronization correlated with the cardiovascular and metabolic status in crew members of the Concordia (at high altitude) and Dumont d'Urville (at sea level) stations, therefore allowing to isolate the effect of altitude (hypoxia) by comparing the results obtained between both stations. Because the crew of the Concordia station is exposed to severe hypoxic conditions and specifically to nocturnal intermittent hypoxia due to sleep apnoea, which has potential major health and functional consequences, a better understanding of the mechanisms by which function and health is affected over time is needed in this specific condition compared to sea level Dumont d'Urville station. The project will also evaluate the effectiveness of new, non-invasive countermeasures for restoring sleep, health, and optimal high-cognitive functions. The methodology is supported with new biotechnological devices for field monitoring of sleep, cognition and emotion providing feedback on individual health status and function.

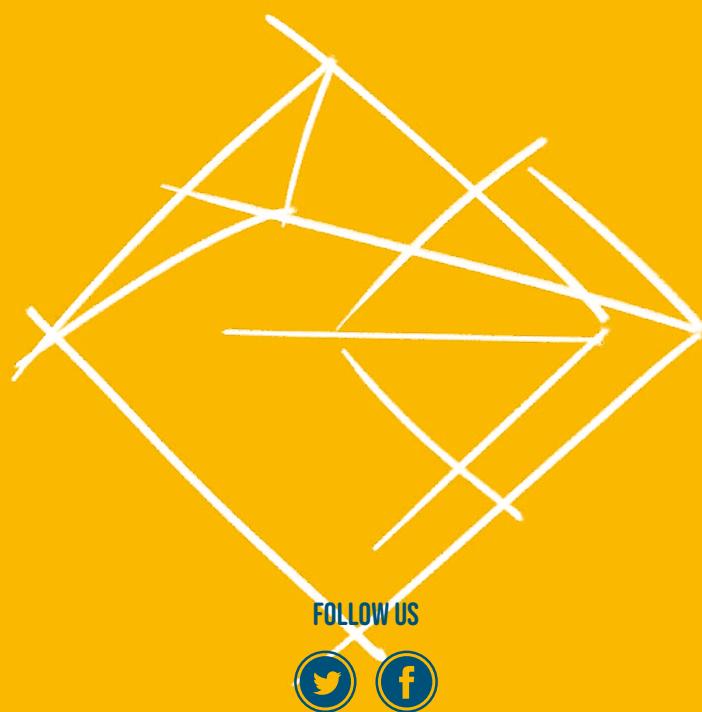


Dumont D'Urville, Concordia
ANTARCTIC



Vergès Samuel





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