BELGIANS AT THE WORLD'S POLES

The fourth International Polar Year

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Editorial

The fourth International Polar Year (IPY 2007-2008) was one of the biggest coordinated international research programmes ever organised. In more than 200 scientific projects, thousands of researchers from more than 60 countries carried out wide-ranging research to better understand the Polar Regions and their critical influence on the rest of the planet.

Like many countries, Belgium had few or none of the extra resources needed to take part in the IPY. However, thanks to ongoing support from the Belgian Science Policy (BELSPO), the Fonds Wetenschappelijk Onderzoek (FWO), the Fonds de la Recherche Scientifique (FNRS), the Inbev - Baillet Latour Fund, etc., and invitations from foreign partners to collaborate on projects, the Belgian polar community managed to contribute actively to the achievements of this ambitious scientific programme.

The most visible Belgian contribution to the IPY was without doubt the Princess Elisabeth station, a new Belgian research base in Antarctica. In 2010 the management of the station was handed over to the Polar Secretariat, a government department within BELSPO. The station is both a model of sustainable technology and renewable energy in practice and an ideal operating base for research in the surrounding Sør Rondane region, where until now little research has been done.

Additionally, Belgian researchers and organisations have taken part – sometimes in a coordinating role – in about thirty projects at the North and South Poles.

This brochure gives a glimpse of Belgian efforts and achievements in the IPY. Though we have sought to be as comprehensive as possible these articles represent no more than a snatch of the rich diversity of Belgian polar research.

With this brochure we hope to demonstrate the continuing relevance of polar research and, at the same time, encourage a new generation of scientists to pursue a career studying these fascinating regions of our planet.

Dr. Philippe Mettens
Chairman of the Board of Directors
of the Belgian Science Policy

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Content

4 'International Polar Years'

Polar research fascinates.
Early adventurers and researchers travelling to the Polar Regions were confronted with the most extreme life and weather conditions on earth. Upon their return, they had countless stories to share attesting to the courage and perseverance required for such undertakings but also filled with information arousing the curiosity of everyone. At the end of the 19th century and during the first half of the 20th century, these polar explorers were often heralded as national heroes, influenced by nationalist movements, and any 'polar expedition' was often merely about planting the national flag nearby or on top of the geographic pole. In many cases, scientific research used to play a secondary role to geographic exploration.

First International Polar Year 1882-1883

Austrian Karl Weyprecht, co-leader of the Austro-Hungarian 'Tegetthof' expedition (1872-74), which discovered Franz Josef Land in the Arctic Ocean, deplored this nationalist approach in his remarkable speech delivered to the Royal Geographical Society in London (1875):

"But as long as Polar Expeditions are looked on merely as a sort of international steeple-chase, which is primarily to confer honour upon this flag or the other, and their main object is to exceed by a few miles the latitude reached by a predecessor, these mysteries will remain unsolved..."

At the same time, he argued fervently in favour of a meaningful and coordinated observational network:

"Decisive scientific results can only be attained through a series of synchronous expeditions, whose task it would be to distribute themselves over the Arctic regions and to obtain one year's series of observations made according to the same method."

Weyprecht's ideas were adopted by the International Meteorological Organization (IMO) and eventually led to the first large-scale international measurement campaign, i.e. the first International Polar Year (IPY) in 1882-83. Eleven nations collaborated to establish 12 research stations along the coast of the Arctic Ocean to perform systematic observations throughout winter and summer of the climate, the magnetic field and the polar light. However, with only two stations located at a relatively high southern latitude, one at Cape Horn and one in South Georgia, Antarctica was very much left out of the scope of the survey.

Second International Polar Year 1932-1933

Fifty years after the first International Polar Year, the second International Polar Year, IPY-2, was organised in 1932-1933 to follow in the footsteps of IPY-1. Forty-four nations participated in IPY-2, including a number of nations from the southern hemisphere, yet once again, they did not succeed in including Antarctica in the measurement network, while on the other hand, the scientific program was greatly expanded to include observations in higher atmospheric strata (aerology), radiation and atmospheric electricity. However, the consequences of the economic crisis of the 1930s threatened many of the initiatives.

Third International Polar Year, or the International Geophysical Year (IGY) 1957-1958

Perhaps frustrated by the plans that failed to come to fruition during IPY-2 and motivated by the proven potential of science and technology during the Second World War, geophysicists Sydney Chapman and Lloyd Berkner launched the idea of organising a new International Polar Year in 1957-1958, only 25 years after the previous one. This third International Polar Year was timed to coincide with the high point of the eleven-year cycle of sunspot activity. The idea was supported almost at once by a large number of geophysicists and by the International Council for Science (ICSU), an umbrella group of scientific organisations. The objective was to study the physics of the earth in its entirety. The field of observation therefore needed to be expanded to include the entire globe, thus leading to the renaming of the International Polar Year (IPY) into the International Geophysical Year (IGY). Naturally, this global approach required the participation of as many nations as possible, including the Soviet Union, which was not a member of the ICSU at that time. The fact that the western powers reached out to the Soviet Union to participate in the IGY was not a simple matter of course, considering that these events took place at the height of the post-war 'Cold War'. The final decision of the Soviet Union to participate in 1955 most definitely accelerated the initiatives of the IGY – and research in the Antarctic regions in particular. No less than 65 research stations were established in the Antarctic by some twelve nations. Most stations were located near the coastline or near the Antarctic Peninsula, which provided easier access. In the difficult to reach interior of the Antarctic, Americans and Russians essentially balanced each other out: two American stations (Amundsen Scott station on the geographic South Pole, and Byrd station) and three Russian stations (Vostok station on the southern geomagnetic pole, and bases Sovetskaya and Komsomolskaya) were the major operating bases for the (scientific) exploration of the high, central ice plateau.

In 1958, with the establishment of the Roi Baudouin base on the coast of Dronning Maud land, Belgium joined the select club of 12 nations (currently 28) who would determine the history of Antarctica from then onwards. Upon completion of the IGY, participating nations were keen to consolidate their efforts. Most nations would hold on to their research stations, and the 'Antarctic Treaty', signed by those same nations, guaranteed the freedom to conduct scientific research and to manage the Antarctic region in an efficient manner, irrespective of the territorial claims made by some.

The legacy of the International Geophysical Year in Antarctica was twofold. On the one hand, a network of permanent research stations was now operational, which meant the true status of the Antarctic region could finally be mapped for the first time, in particular regarding climate conditions, such as extremely low temperatures, high wind speeds, the condition of the higher atmosphere and its relationship to the solar wind, but also regarding the

shape and depth of the ice cap (dome-shaped topography, ice thickness of more than 4 km in certain places) and sea ice expansion, the existence of ice-free regions such as the dry valleys of the transantarctic mountains and coastal oasis areas, etc.

On the other hand, the IGY effectuated a unique form of management, with only those nations performing substantial scientific activities in Antarctica also having the power of decision at the annual Antarctic Treaty Consultative Meeting (ATCM). This now ensures that Antarctica remains a continent devoted to science and peace.

Fourth International Polar Year 2007-2008

During the fourth IPY 2007-2008 – fifty years after the success of the IGY – a new wave of research activities (approximately 230 approved projects!) was organised through the ICSU and the WMO (World Meteorological Organisation – the successor organisation of the IMO). Whereas the main focus of the IGY was on opening up the Antarctic region from a scientific point of view, this time the majority of projects (more than 50%) focused on the Arctic regions. Perhaps this had something to do with the end of the Cold War, which made the expansive Russian arctic region suddenly more open to international partnerships, but perhaps also because of the specific impact of global warming on the northern ecosystems and on human society. A schematic overview of the main differences between the current IPY and the highly successful IGY in view of the Antarctic region is summarised in the table below. The main difference undoubtedly lies in the more thematic approach versus the disciplinary approach, or in other words, the growing trend towards problem-solving science and new frontiers (such as subglacial processes) as well as the pluridisciplinary approach with a striking increase in oceanographic and biological input. Scientific research into the ecosystems in and around Antarctica has led to scientifically justified measures for environmental protection. The Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) and the Madrid Protocol (Protocol on Environmental Protection to the Antarctic Treaty) are both treaties that have been added to the Antarctic Treaty system, making environmental protection one of the dominant items on the agenda of the annual Antarctic Treaty Consultative Meeting, and leading to Antarctica being officially listed

as a natural reserve. One of the main legacies of the most recent Polar Year is the construction of approximately 4 new, high-technological bases, including the Belgian Princess Elisabeth station, which aims to set an example of how activities can be conducted in an environmentally friendly manner while minimising the impact on nature.

IGY (1957-1958)	versus	IPY (2007-2008)
Large number of new stations (65)	↔	A select number of high-technological stations (approx. 4)
Thematic approach	↔	Disciplinary approach
Qualitative scenarios and models	↔	Numerical scenarios and models
Emphasis on geophysics and solar-terrestrial phenomena	↔	Emphasis on sociological, climatological and environmental research
Biological and oceanographic research was not part of the core business	↔	Research into (micro)biodiversity, biogeochemical cycles and oceanographic research
Geological research in support of potential mineral exploitation	↔	Geological research in support of plate tectonics and climate history
Exploration of an unspoiled continent	↔	Preservation of unspoiled nature
Research into surface characteristics of the ice cap and the oceanic environment	↔	Research into the subglacial environment and the deep ocean
Operations primarily reliant on ship transport	↔	Network of aeroplane operations and satellite observations
Establishment of a political regime (ATCM)	↔	Implementation of and support towards environmental protection (Committee for Environmental Protection, CEP)
National expeditions	↔	International and multidisciplinary research teams

The Polar Secretariat, the Belgian Science Policy's new service

One of the most impressive technical feats achieved within the framework of the International Polar Year is undoubtedly the construction of the new scientific research station in Antarctica: the Princess Elisabeth Station. This 'zero emission' building and its annexes, built by the International Polar Foundation (IPF), were handed over to the Belgian State in 2010. To ensure an optimal management of the station, a separately-managed state service was set up: the Polar Secretariat. Just like other similar structures dedicated to research or culture, it falls under the authority of the Belgian Science Policy (BELSPO). Interview with the President of BELSPO, Dr Philippe Mettens.

In which context was the Polar Secretariat set up?

Philippe Mettens: The financing of the station built by the IPF was considerable for the Belgian state. We invested more than EUR 13 million in it. What's more, we wanted to avoid the King Baudouin base syndrome (erected in the 1950s within the framework of the International Geophysical Year), meaning that we wanted to be able to maintain a significant and recurring level of investment for this station and the running of it. Hence, the issue of public involvement was quickly raised. Therefore the base was transferred to the state. It's the Belgian Science Policy that takes care of its operational management through a partnership with the IPF.

In order to have a sufficiently flexible and efficient management structure, a completely new service dedicated to this mission was created within BELSPO: the Polar Secretariat, a separately-managed state service. It's an organisation like other similar services created in the past, which run very smoothly. Such is the case for Belnet, for instance, the Belgian data communications network dedicated to research, or the federal science establishments which have a similar status.

The benefit of this status is indeed attractive. As a rule, public services can't generate revenue and allocate it to its missions or to hiring staff. A special accountant status is required for this purpose. This is what a separately-managed state service can offer. It's a flexible structure with flexible management bodies, which is authorised to receive funds through foundations, such as the Inbev-Baillet Latour Foundation or the Cercle Gaulois, which has just started a fund in aid of recruiting an additional researcher within the context of work carried out at the Princess Elisabeth Polar Station.

The idea is for these funds to converge for the benefit of the Polar Secretariat, which can rapidly allocate them to its missions. This allows an optimum use of the base.

You mentioned the public-private partnership; what exactly are your alluding to in this context?

The Polar Secretariat, i.e. the Belgian Science Policy (BELSPO), has set up a public-private partnership by joining forces with the International Polar Foundation (IPF) through an agreement. The latter carries out logistical missions. The IPF manages all the logistical aspects of the missions organised at the Princess Elisabeth Station, organises travel, freight transport, security on site, etc.
Multiple collaborations exist and can be developed within this context.

In particular, with the Ministry of Defence, which has a great deal of expertise in many domains that could help with the smooth running of operations in Antarctica. For instance, the mechanics and logisticians who come to provide support.

Who is in charge of the Polar Secretariat?

On the one hand there is a director and on the other a management body; the Strategic Council has been set up for a five-year term. All the federal departments that are involved in one way or another in research in Antarctica are represented within this council: the Belgian Science Policy, in charge of research in Antarctica; Foreign Affairs, which is the point of contact for activities linked to the Antarctic Treaty; Environment, responsible for authorising activities in Antarctica; Defence and the Prime Minister's services.

Quite surprisingly, the federal departments are represented by ministerial cabinet representatives, whereas civil servants usually ensure the continuity of public services in this sort of body.

Half the members of this management body are from federal departments. The other half of its members are from outside the public service sector. Even if they are from private companies, we don't refer to them as 'private'. As soon as they are members of a public service management body, they belong to the civil service.

The public-private partnership in question here is therefore not situated within the Polar Secretariat's Strategic Council. It lies between the Strategic Council (i.e. the Polar Secretariat) and the International Polar Foundation, which is, in fact, a foundation of public interest. IPF is the 'private' partner here.

Does the Polar Secretariat decide which research programmes to conduct?

The Polar Secretariat provides an interface with the operational and logistical structures in Antarctica but also with the services that manage the research programmes, in particular, the research programmes in Antarctica, those concerning climate change, sustainable development, etc.

These interfaces may concern space research and activities or the federal museums, some of which may be of interest to these scientific issues (IRM, IRScNB, etc.). Therefore, it is indeed an interface with the outside world, IPF, and all possible sources of finance. It also provides an interface with BELSPO's various services, which ensure coherence between the scientific activities.

The Belgian Science Policy can't envisage financing activities in Antarctica without taking into account what happens at the Prince Elisabeth Station. On the other hand, all our polar programmes are not exclusively related to this Antarctic station. Many researchers have been working for years on other aspects. Marine biology for instance. The role of BELSPO is to ensure the continuity and coherence of all these polar programmes.

Better still, with the advent of the new station, additional means have been released. These means will ensure the smooth running of the Polar Station's activities but will also finance all the polar-related programmes.

Therefore, BELSPO remains the sole master on board with regard to the management of scientific research. This ensures the constancy, independence and control of these programmes.

Climate change in the Antarctic

Twenty-five million years ago Antarctica was rich in plant and animal life. There were forests. There were large marsupials running around. There was an abundance of species. When the Antarctic continent started cooling and was slowly covered in ice, life withdrew to a few places of refuge: those rare places that were not entirely covered by the ice sheet.

By then, of course, the large marsupials had already disappeared. All the higher species died out but, to this day, we still find simple life forms in those refugia: all kinds of microbes and arthropods, such as springtails, mites, nematodes, etc.

There are little lakes and pools, almost of all them near the coast, that get covered in a thick layer of ice in the winter, but contain liquid water under the frozen surface. Where there is water there is life. Even in Antarctica. It is the last place of refuge for Antarctic life. And it is the best possible working environment for Ghent researchers Wim Wyverman and Elie Verleyen.

1 Elie Verleyen
2 Wim Vyverman

Wim Vyverman:
We first visited one of these Antarctic 'oases' in the late 90s: the Larsemann Hills, in the Australian sector of East Antarctica. Even in the coldest periods, in the last glacial maximum, there were parts of the area that were free of ice. Due to the local geology the glaciers were forced to flow around the hills and not over the top of them. Places like this are of extreme interest from an evolutionary perspective: they are the last places in which land life, or life in water on the land, is possible. The habitats are remote from each other and very small. They are the ideal places to study all of the processes of change and extinction in organisms. They are a sort of natural laboratory in which to study evolution. The beds of the coastal lakes also contain sediment, which holds traces that allow us to study the history of the area.

Climate change has an impact on ecosystems around the world, including the tropics, but the poles are of interest to science because there are huge temperature differences and they react to climate change extremely quickly.

Has the International Polar Year yielded anything in your field of study?
IPY was an opportunity for us to get out and about more and activate the network of international contacts we had already built up. It came down to achieving the 'critical mass' we need in the area of Antarctic microbial ecology. Lately there has been a lot of innovative research in the area of microbial ecology, because new technologies now allow studying microbial communities in natural settings. Our research has demonstrated that key scientific questions in microbial biogeography can be tackled by looking closely at the ecology of the Antarctic microbes.

3 4

3 Elie Verleyen and Wim Vyverman take a core sample of sediment from a lake in West Ongul (Lützow Holm Bay, East Antarctica).
4 Wim Vyverman measures the temperature, pH and conductivity of the water in a lake in Langhovde (Lützow Holm Bay, East Antarctica).

Elie Verleyen:
I do paleoclimatological research using diatoms and the fossil elements of micro-organisms that we find in these Antarctic lakes. By looking at the species that appear in the different layers of sediment we can find out what the climate was like in the past.

To mark the International Polar Year the SCAR (Scientific Committee on Antarctic Research) wanted to publish a book giving an overview of everything we know about Antarctica, about Antarctic ecosystems and about the effect of climate change on the ice sheet. As scientists working in terrestrial environments, Wim and I were asked to collaborate on the book. It turned into an 800-page tome that was published in 2009: the Antarctic Climate Change and the Environment (ACCE) Report.

The work we did on the book brought us in contact with people all around the world. We formed a team of scientists and that collaboration has now resulted in an article published in Earth Science Reviews.

The article is about climate change along the southern Antarctic coast during the Holocene, a warm period that started after the last ice age and in which we now live. Our knowledge of climate fluctuation largely rests on ice cores from the Antarctic high plateau and sediment cores from the sea. But the coastal ecosystems we are studying actually bridge the gap between the terrestrial cores and the deep sea sediment cores.

We have discovered, for example, that there was a warmer period in the early Holocene, i.e. between 11 500 and 9 500 years ago! Many of those coastal areas were then free of ice due to the warmer conditions. The sea level rose because ice sheets were thawing in the northern hemisphere. There was also a second warmer period in Antarctica between 4 000 and 2 000 years ago. We are finding traces of this on the Antarctic Peninsula, but no corresponding traces in the northern hemisphere. There was no warmer period in the North between 4 000 and 2 000 years ago. It seems as though the North and South have different climate histories.

Is this a significant discovery thanks to the IPY?
I have been hard at it for ten years since my doctorate on the sediments in the Larsemann Hills. Over the years we have built up a network of scientists who are all pondering the same questions. But the International Polar Year has encouraged us to share our conclusions.

This specimen of fuchsia was found on King George Island (C. De Broyer).

SCAR-MARBIN : A leading belgian project for the international polar year

Among the projects under the International Polar Year aegis in which Belgian researchers took part, there was one of particular importance, namely the SCAR-MarBIN (SCAR – Marine Biodiversity Information Network) project, SCAR being the Scientific Committee on Antarctic Research). And with good reason, because this international project was managed from Belgium as part of the Belgian Biodiversity Platform. Initiated by Claude De Broyer and Bruno Danis of the Royal Belgian Institute of Natural Sciences, SCAR-MarBIN is today a true success story!

The origin of this adventure was quite simple at the end of the day, explains De Broyer. We had a very clear initial idea: there is an abundance of information on marine biodiversity in Antarctica. The Southern Ocean is extremely rich as regards biodiversity and numerous studies have already been conducted on it. Unfortunately, this mass of scientific and technical information is very widely dispersed and fragmented. It must also be said that part of this information is being lost. There was therefore a need to take the initiative, to make an effort to collect and verify all the data from all those researchers, but also from other sectors such as fishing and nature conservation.

Moreover, in the context of sustainable development objectives, the United Nations decided to establish a network of marine conservation areas all over the world by 2012, including in Antarctica. Before creating those zones it is evidently necessary to have a good knowledge of how biodiversity is distributed. This is at the root of the fundamental idea of the SCAR-MarBIN project, which answers the question: why not make all that scattered data available to the largest possible number of users, for the purposes of research, conservation and sustainable management of the environment and living resources?

Once the idea was launched it was necessary to define the main aims of the project. This was not a matter of creating a single giant database incorporating everything that was available from every corner of the globe. We preferred to create a network linking existing databases, a network of interoperable and coordinated databases, says De Broyer. This allows everyone to manage their data in the way they want, to improve the compilation and content at their own pace and according to their resources, while making what is already in existence available to all researchers.

The project took off on the occasion of the International Polar Year, under the auspices of the SCAR, which actively promotes international scientific cooperation. This project started in 2005, mainly thanks to funding from BELSPO, but also from other partners, including, at the start, the global CoML (Census of Marine Life) project, supported by the Sloan Foundation in New York.

The embryonic SCAR-MarBIN project was in the first place carried by the partners in the Belgian BIANZO project. This research project involved studying biodiversity in benthic Antarctic communities. De Broyer worked on amphipod crustaceans, an extremely diverse group in the Southern Ocean, which he made his speciality.

The University of Ghent team, also a BIANZO partner, concentrated on nematodes. Finally, the Université libre de Bruxelles and the Université de Bourgogne (France) also participated in this project by studying echinoderms (sea urchins).

In the first place, the databases of the various Belgian partners referred to above were linked in a network with a view to studying the feasibility of the project. The project has taken on an entirely different dimension since under the aegis of the SCAR. The partnership and the coordination of the databases have become 'planetary.'

The Belgian partners also participated in the launch of the CAML (Census of Antarctic Marine Life) project. This specialised census of Antarctic marine biodiversity forms part of the wider context of the global CoML programme. CAML pursued three main objectives: studying biodiversity by intensifying marine exploration and collecting, understanding species distribution better and, lastly, evaluating their abundance. Overall, CAML ended up involving 19 campaigns conducted by 300 researchers from 15 countries. Most of these campaigns took place in lesser-known areas of the Antarctic Ocean and explored depths that had never been reached before. The data collected in this context will also enrich the SCAR-MarBIN network.

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Today SCAR-MarBIN has reached a global level of usefulness that is recognised by all its partners, says Claude De Broyer. All the world's Antarctic institutions contribute to it. The information to be found there is also very relevant and has all been verified by the most expert scientists in their fields.

What exactly will you find in this set of databases? Two main types of information. There is firstly the taxonomic data. The main data is found in the 'RAMS' (Register of Antarctic

Sea anemone "*Actinie Bouvet*" (M. Rauschert).


CUMA Cyclaspis gigas
St.293 M. RAUSCHERT.


Anchiphimedia dorsalis-M.
RAUSCHERT (AWI) -WED


LYSIANASSOIDEA Waldeckia obesa
ANTXXIII-8 sta 686-1 C. d'Udekem
d'ACOZ (IRSNB-KBIN)


ISOP Natatolana
St. 167 M. RAUSCHERT


EPIMERIIDAE Epimeria
robustoides M. RAUSCHERT (AWI)


LEPT Nebalia
2 St 253 M. RAUSCHERT


Epimeria grandirostris
MRauschert (AWI) -WED


ECHI Holuthurie
St.307 M. RAUSCHERT


Cyllopus lucasii-WED
M. RAUSCHERT (AWI)

Figures

SCAR-MarBIN: 50 million viewings and downloads.
No one can dispute the success of the SCAR-MarBIN project with the support of Belgium.
The numbers don't lie!

SCAR-MarBIN now gives access to **196 databases** around the world. These databases reflect the participation of all the major institutions active in the Antarctic.

8 500 species included in these databases have been scientifically 'validated.' More than 80 marine fauna specialists around the world have 'certified' them. Each of them has verified the names, features and data for each species in their group.

1.2 million distribution data can be accessed. This network is particularly rich in data on the distribution of species. Here you will find information on the species that have been collected, their exact location, and other kinds of information, all of this since the expeditions of Captain Cook in the 18th century!

50 million downloads. Finally, as regards users, the counter has already passed 50 million data downloads since the network went online in 2005.

www.scarmarbin.be
www.antabif.be

Marine Species). This makes it possible to gain an accurate idea of the species richness in the Southern Ocean and to establish an indispensable basic reference as regards naming and classification. There are then the data on the location of samples: longitude, latitude, depth and local environmental observations. This may appeal dull, but this is important data, all the more so given that this type of data has been available since the early days of Antarctic exploration. De Broyer comments that: In fact we know the precise location of the areas where specimens were collected in the course of time for most groups of species. This register in particular contributes to 'WORMS' – the World Register of Marine Species.

The future is already taking shape. The network partners are working on its development by adding supplementary sources of information, with new taxonomic identification, imaging, cartographic and analytical functions. This will in particular make it possible to compare the cartographic layers where species occur with a whole series of environmental data: the water temperature, salinity, currents, nutrients, etc. This kind of data is also available for other species, not only for crustaceans, but also for fish, octopuses, squids, sea stars, birds, mammals, etc. Another type of data needs to be developed further to improve this gigantic x-ray of Antarctic marine biodiversity, namely data concerning the abundance of species.

What is more, SCAR-MarBIN now is part of AntaBIF, a new BELSPO project, which is intended to connect all the data relating to Antarctic biodiversity, terrestrial as well as marine, in the same way as SCAR-MarBIN, and more specifically data generated during scientific research performed at the Belgian Antarctic Princess Elisabeth base.

The SCAR-MarBIN project did not end with the International Polar Year. One of the major current developments for SCAR-MarBIN concerns developing a new biogeography of the Southern Ocean. This involves setting up a map of the distribution of animals and marine algae, their distribution zones, and combining this with sound explanations on their distribution.

The most recent biogeographic overview of the Southern Ocean dates from 1969, says this researcher from the Royal Belgian Institute of Natural Sciences. Now we have a unique chance to update it with the CAML and SCAR-MarBIN. At this time, 62 researchers are verifying and adding to the distribution data, studying the origin of the taxonomic groups, and explaining the distribution of species. We will then develop distribution maps and state the factors underlying this distribution of species. Finally, this tool will make modelling possible. This will help us to make projections for the future. By modifying certain environmental parameters, we will be able to predict how populations might evolve in space and in time.

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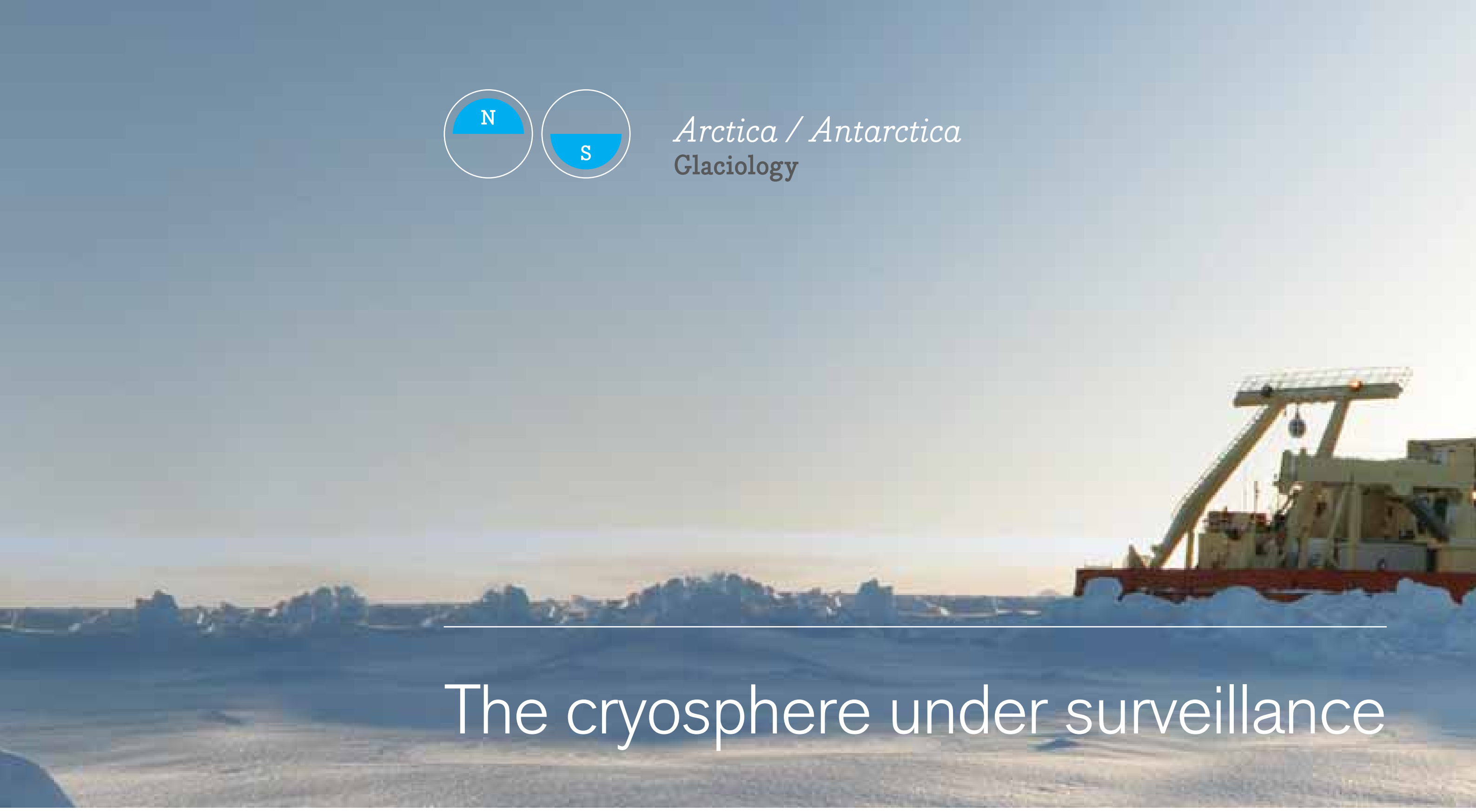

The cryosphere under surveillance

The American icebreaker Palmer at the SIMBA project site.

Whether it concerns the ice caps of the Antarctic or Greenland, the pack ice of both hemispheres, other floating ice bodies, or even the flow of land glaciers, the study of the cryosphere attracts the interest of many Belgian researchers. They redoubled their efforts during the International Polar Year. Their research programmes covered numerous themes. Of course, researchers do not just study ice for its own sake. Ice allows us to read the history of our own planet, to follow clues on its role in the global climate mechanism, and gives us information on the connections between the atmosphere and the oceans. From the observation of the dynamics of Earth's natural ice masses to ice biogeochemistry, while also developing sophisticated models at all scales (climate or others), Belgian researchers brought their full attention to the cryosphere during the IPY. Here's the story.

Ba²sics

(Biogeochemistry of Antarctic & Arctic sea Ice and Climate change)

This international programme was widely supported by Belgian teams, mainly via the SIBClim (Sea Ice Biogeochemistry in a Climate Change Perspective) consortium. The ULB, ULG and UCL teams were interested in energy and mass exchanges between sea ice, the ocean and the atmosphere as well as the impact of these fluxes on the Climate.

In the context of the IPY, the Belgian SIBClim programme internationalized and developed an interest in the North and South Pole regions, which resulted in Ba²sics. Three field campaigns were undertaken in the context of Ba²sics. These concerned the research projects SIMBA (Sea Ice Mass Balance in Antarctica), conducted in the context of the IPY-ICED project; CFL (Circumpolar Flaw Lead), in the Canadian Arctic (IPY-CFL project), and Arctic Landfast Sea Ice in Point Barrow, in Alaska (IPY-PACSIZ project).

It should be noted that this work led to some great discoveries. It was for example possible to show that sea ice contains up to a hundred times as much iron as surface waters in the polar regions, encouraging plankton blooms in the spring.

ICED

(Integrating climate and ecosystems dynamics)

Pack ice plays an important role in the Earth's climate system and for the associated ecosystems, and not only because it is able to reflect incident solar radiation. Biological activity in the pack ice is also likely to play a major, although still largely understudied, role in the greenhouse gas cycle. This is a matter of interest for Belgian researchers (Jean-Louis Tison at the ULB or Bruno Delille at ULg).

Is there life in sea ice? Of course. It harbours algae, primary producers, which consume carbon dioxide. These organisms have to resist very low temperatures in pockets of liquid water where the salinity level is very high (up to 200 grams of salt per litre, compared to approximately 34 grams of salt in sea water). To survive in such extreme environments, algae produce sulphur containing compounds. These compounds break down into a sulphurous gas, which in turn escapes into the atmosphere, where it ends up oxidising and so forming sulphates, aerosols which have the opposite effect to greenhouse gases. They limit the supply of incident energy, block the sunrays, and moreover form nucleation sites where vapour condensates, increasing the cloud cover and clouds density.

In short, although unknown among the flood of data which currently feeds into climate models, the data related to the activity of these organisms, potentially derived from some 28 million square kilometres of sea ice, very likely has an important role to play with regard to climate. Apart from that, the CO_2 concentration in the pockets of brine dispersed in the sea ice are virtually nil (zero ppm). We know that, because of massive man-made CO_2 emissions since the industrial revolution, the concentration of CO_2 in the atmosphere is now of the order of 400 ppm.

As a result, atmospheric CO_2 diffuses in the pack ice and is then captured by algae, which eventually die and sink to the bottom of the oceans. Scientists in Liège and Brussels are also studying how greenhouse gases are transferred towards the seabed (natural trapping of carbon). The role of biological sea ice communities (sympagic) in controlling the fluxes of greenhouse gases is at the heart of the work being conducted by Belgian scientists. They are also studying this aspect of the biogeochemistry of ice and its impact on the climate.

CFL

(Circumpolar flaw Lead)

CFL was the most important Canadian research programme financed in the context of the IPY. It was open to international collaboration. Naturally, Belgian glaciologists took part in it.

CFL looks at 'leads'. A 'lead' is an opening in the sea ice cover, or a channel. In the Arctic, the Belgians worked between Greenland and the Canadian islands located to the east of the Beaufort Sea, off Banks Island. This is a zone covering several hundred square kilometres where the Arctic gyre connects with neighbouring waters, says Jean-Louis Tison (ULB). The field campaigns were run on board the icebreaker Amundsen between November 2007 and June 2008. Eight Belgian teams took turns on board the Amundsen during this campaign.

The 'lead' or separation channel forms in the sea ice and lasts all through the winter. It gives an exceptional opportunity to study the Arctic Ocean in terms of its main physic-chemical and biological processes, its marine ecosystems, contaminants and greenhouse gases, as well as carbon and nutrient cycles.

Biological activity in the pack ice is also likely to play a major, although still largely understudied, role in the greenhouse gas cycle.

1 The SIMBA project team at the 'Brussels' station.
2 Meteo tower at Barrow (PACSIZ).

PACSIZ

(integrated biophysical sea-ice observatory in the PACific Seasonal Ice Zone)

Belgian scientists also took part in the study of landfast sea ice and its development over time in the context of this other IPY project concerning the Arctic Ocean. The surface of the sea ice is not only shrinking but it is also becoming thinner with global warming. Of this fast evolving process, networks of buoys were deployed under the initiative of the Institute of Geophysics of the University of Alaska at Fairbanks.. These buoys were used to record the growth of the ice, its elevation above the water level, its salinity, temperature, ... Moreover, a Belgian meteorological 'tower' was used to measure CO_2 fluxes using « eddy covariance » at the 'Barrow sea ice observatory' in Alaska. This operation was not at all as easy as it seems, because of the polar bears and foxes who often came to chew on the tents, cables and equipment used by the scientists. Quoting one scientist: «It's harder in Alaska than in the Antarctic!»

Another aspect is also significant: these campaigns, led by Prof. Hajo Eicken of the University of Fairbanks, mainly focused on the ice which remains attached to the coast (landfast sea ice), a very peculiar type of ice which accumulates sediments, methane, and other compounds of climate relevance.

ASPeCt

(Antarctic sea ice processes & climate)

This project, under US-Australian leadership, looks at sea ice processes in the Antarctic, as the name suggests. Although this concerns geophysics as much as biogeochemistry, in the beginning this project only aimed at a physical study of the pack ice, its movements and distortions, measurements that are often obtained using buoys carrying instruments. Belgium took part in this programme also under the IPY banner, in particular via BELSPO, which financed one of these buoys as a component of the SIMBA mission.

3 4

3 Taking samples in the pack ice.
4 Temperature measurements of the sea ice (SIMBA).

GEOTRACES

(Identification and studies of trace elements and their isotopes in the marine environment and their cycles following environmental changes)

Delphine Lannuzel, Véronique Schoemann and Jeroen de Jong, as members of the team of Jean-Louis Tison, did measure iron, a trace metal in sea ice, a very tricky exercise, given that the sea ice iron content is so small. Results were obtained nonetheless which show that iron probably mainly derives from zones where cold water rises from the ocean bottom (upwelling) and is preferentially incorporated into sea ice, as opposed to other impurities, thanks to physico-chemical and biological processes that are not yet well constrained. The sea ice therefore plays the role of a natural storehouse. When sea ice melts, the iron becomes a micro-element nutrient, which fosters algal blooms. These in turn pump down atmospheric CO_2 by means of photosynthesis.

SALE-IPY

(Subglacial Antarctic Lake Environments)

This project, led by an American researcher, focused on an inventory of sub-glacial lakes around the world, mainly in Antarctica. This inventory was supported by seismological and geophysical studies of these environments as well as a clearer understanding of the ice dynamics of those lakes. Naturally, the biology of the waters of these lakes, which have often been cut off from the rest of the world for thousands of years by the thick Antarctic ice sheet that recovers them, has also aroused the curiosity of researchers.

One of the Belgian partners in this programme was none other than Frank Pattyn (ULB). He was particularly interested in modelling the flow of continental ice across these sub-glacial lakes. This ice, which is sometimes several kilometres thick, behaves like an ice shelf, he says.

1 Filtering samples aboard the Palmer (SIMBA).
2 Working trench of the NEEM ice coring project in Greenland.

It floats on the lakes. Frank Pattyn is also interested in hydrologic networks, the flow connections that exist between these various lakes. One empties into the other on a regular basis, which can also be detected by surface elevation changes. It should be noted again that the IPY setting was used to perform a new survey of these Antarctic lakes.

Moreover, Jean-Louis Tison (ULB) was also involved in this project, studying potential indicators of life in these extreme environments. Tison is interested in the presence of these lakes, which may have been isolated for millions of years at the ice- bedrock interface, mainly with respect to the gases that are retained in these deep ice masses. Their signature can indeed tell us a lot about past or present life in this unique environment, a potential proxy for extra-terrestrial habitats.

NEEM

The Greenland ice reveals the Eemian climate

The international project called NEEM (North Greenland Eemian Ice Drilling) is an ice bore hole drilled in the North of Greenland, which was placed under the IPY banner. Analysing gas bubbles captured in the ice, determining their isotopic composition, studying dust and grains of sand or pollen captured in every slice of ice, allows researchers to reconstruct the evolution of the Earth's climate. Belgian glaciologists are involved in this project, the 'drilling' phase of which is soon to be concluded.

With the NEEM project, researchers mainly wish to focus on a specific period of the Earth's climate history, the Eemian. This period started about 140 000 years ago. At that time, the Earth's average temperature was hardly a few degrees higher than it is now, and after that it drastically decreased to enter the last glaciation period. Understanding the reasons for this may help us to understand what is happening now on Earth and perhaps to predict the planet's ultimate climate evolution.

Ice surveys in Antarctica have made it possible to go back more than 800 000 years in time. The ice bore holes in Greenland do not go that far, but they do allow us to describe the past environment in more details. Neem is the latest bore hole of that type to date. The previous deep drillings in Greenland made it possible to push climate history back 100 000 (GRIP and GISP bore holes) and 123 000 years (NorthGrip bore hole).

Difficult working conditions at the 'Brussels' station

Modelling the evolution and stability of the Greenland ice sheet.

Researchers believe that the glacial ice cap which covers Greenland could be seriously 'destabilised' by the current warming of the Earth. In other words, it could start to lose a large part of its mass very quickly through melting and calving (iceberg release), which could in turn have an impact on the mean level of the seas and oceans. Philippe Huybrechts is participating in an IPY project at the Vrije Universiteit Brussel (VUB) aiming at modelling this development, in collaboration with his colleagues at the Université Catholique de Louvain (Profs. Thierry Fichefet and Hugues Goose and their team). He mainly grounds his work on data dating from the Eemian. Researchers are interested in several questions. Is the ice cap going to virtually disappear? If the climate gets colder again, will it rebuild? How will this happen, ...?

The whale

For a long time it was thought that whales were fish. But instead of gills they have blowholes, which is a sign that they have longs. They also suckle their young, which makes them mammals.

There are lots of species of whale, such as the blue whale, the humpback, the white whale, the grey whale, etc. Some are over 33 metres long and weigh more than 100 tons, others are no bigger than a human being.

Scientists distinguish between two groups of whales, i.e. toothed and baleen whales (they have baleen plates instead of teeth, which enable them to filter food from the water). Sperm whales, which belong to the toothed whale family, eat squid, cuttlefish and octopus. Killer whales sometimes eat fish and shellfish, or may eat other whales and mammals.

Our teacher went to the North Pole

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1 Mieke Eggermont (left) with Katja Guilini (Marine Biology Ugent).
2 The German icebreaker RV Polarstern in Spitsbergen.

Mieke Eggermont is a young biology teacher who got the chance, along with a colleague from Norway and one from Germany, to travel to the Arctic Ocean aboard the German research vessel, the Polarstern.

Mieke Eggermont:

It was Professor Jean Pierre Henriet who got me into polar research. I was teaching part-time at the Koninklijk Atheneum on the Voskenslaan in Gent when I discovered, to my amazement, that I loved standing in front of the class. I had studied as a vet, specialising in pets, and to boost my knowledge a little I had started studying again. I got lessons in marine geology from Professor Henriet and in the first lesson he asked the class if anyone would like to go to Antarctica. I put my hand up. I was the only one in the auditorium. If you really want to, you'll have to go for it! he said.

At the start of the International Polar Year our school took part in the IPF class@poles competition. The assignment was that the pupils themselves pose a scientific question and then work out how they would go about the study. The exams had already started, but with a bit of help we managed it: one of our pupils, Werner Dewaele, wanted to know if the Inuit, the indigenous people of the North Pole region, were feeling any detrimental effects from the pollution we cause here in the South. He had thought up a wild expedition involving lots of airplanes and helicopters and, lo and behold... he was among the winners. As a prize he was given a trip to Ny Alesund on Svalbard (Spitsbergen), to the most northerly university in the world. A dream trip!

We could freely move around on the ship with 50 scientists aboard who were unable to escape our curiosity.

And then Professor Henriet asked me whether I still dreamed of the poles? Come on! He had been on lots of expeditions himself aboard the Alfred Wegener Institute's Polarstern icebreaker and, thanks to his contacts in Germany, he was able to secure a few places on board. I got the opportunity, along with a colleague in Germany and a

Norwegian teacher, to go on the three-week trip. In early July 2007 we boarded Polarstern in Longyearbyen, the capital of Svalbard, and three weeks later we left her in Tromsö, Northern Norway. It was fantastic! We could freely move around on the ship with 50 scientists aboard who were unable to escape our curiosity. We were able to ask anything we wanted to. The sun shone 24 hours a day. We only slept 3 hours a night. I even thought it a shame that we had to sleep at all. There was even a researcher aboard from my hometown, Ghent, Katja Guilini, and she was on Professor Ann Vanreusel's team studying nematodes (round-worms).

The Polarstern went to Hausgarten first, which means 'back garden' in English. It is an area to the west of Spitsbergen, which the vessel visits every year because scientists from various countries are there doing research all year round. Instruments have been anchored on very long ropes, known as moorings, and they collect data at different depths of the water column. A radio signal from the ship automatically frees the moorings from their anchorages. The Swedes used steel tram rails. They rust away over 100 years. Once released, it takes a few hours for all the instruments to float to the surface from the 2 000 metre depth. We were able to follow the whole operation on board. We asked the captain if we would be sailing through pack ice. We really wanted to see pack ice, but Hausgarten lies in an area that usually stays ice-free. So no luck. Until one morning we woke to find that the pack ice had drifted towards us. The Polarstern was completely surrounded by ice. Magical. It wasn't much fun for the crew. To get the instruments back they had to break up the ice. It was very hard work. But we thought it was brilliant.

We also had an ROV (Remotely Operated Vehicle) on board, a remotely operated submarine that was capable of going to

3 Shrimp on a sponge at a depth of 4 000 metres.
4 Instruments floating at the surface in the Hausgarten area.

a depth of 4 000 metres. The camera images it sent back could be seen on large screens all around the ship. At one time it was pointed at a huge sponge. Crystal clear. Suddenly a prawn climbed onto the sponge. At a depth of 4 000 metres! That certainly is fantastic!

Two years earlier the crew of the Polarstern had left a dead whale, weighted down by a steel frame, on the sea bottom. They wanted to know what would happen to the huge body at great depth in that desert. Last year the Polarstern wasn't able to return to the location. It was pretty exciting, then, to see what might be left of the whale after two years on the seabed. We had the right coordinates, but there was nothing more to be seen. Just the steel frame. It seems that every last trace of the whale had been eaten by some sort of headless shrimps (deep sea amphipod). They are scavengers that come from far-and-wide if they smell rotting flesh in the water. Or should I say taste? Whatever the case, we pulled a few of those shrimp up in a net and (surreptitiously) threw them on the barbecue. Delicious.

The Arctic Ocean is also the location of a huge a pump that drives the flow of ocean currents around the world. The warm Gulf Stream at the surface is part of this. Water that is both salt and cold is high in density and sinks to the bottom. It pushes the water mass at the bottom away and sets up a motion. But these processes take place over hundreds of years. Only now are the consequences of the industrial revolution and the ensuing pollution being transported to the bottom of the deep sea. One of the most interesting experiments involved a camera carried along in the current one metre above the seabed. The camera took a photo at regular intervals and, later, scientists were able to work out how much microbiological life there was to be seen in the photos. Four years later they did the experiment again. It appeared that the number of animals and plants had halved! Isn't that scary? Now they want to know whether it was a coincidental fluctuation or whether we really are seeing a dramatic decline in plant and animal life in the deep sea.

The scientists may be being a little overcautious. They don't normally tend to sound the alarm. In the meantime, though, policy remains as it was. When you are standing in front of a class of youngsters you have to say something. It is their world. They decide tomorrow's public opinion. Maybe it's a good thing if Miss goes to the North Pole every once in a while. Every young convert counts. One individual can make the difference.

The Belgian Royal observatory manages the GIANT-LISSA programme

1 2

1 Permanent GPS station.
2 Denis Lombardi with a seismometer.

The giant icecap which covers the Antarctic plays a major role in the deformation of the underlying continent. To study this impact and the ground movements that result in particular from the variation in this ice mass (such as the melting of the icecap, accelerating ice flows, changes to the accumulation of snow, etc.), the researchers at the Belgian Royal Observatory are engaged in two research projects, in collaboration with various international partners, namely Polenet and GIANT-LISSA.

Polenet (Polar earth observation Network) studies the geodynamics of the polar regions, the planet's magnetic field, as well as the interactions between the Earth, the cryosphere, the oceans and the atmosphere. This project is part of the International Polar Year. The Belgian (the Belgian Royal Observatory, the Royal Military Academy) and Luxembourg scientists (University of Luxembourg) concentrated their efforts in this context, with the support of BELSPO, via the GIANT-LISSA (GIANT = Geodesy for Ice in ANTarctica and LISSA = Lithospheric and Intraplate Structure and Seismicity in Antarctica) project.

We are not only fortunate to have a research base in Antarctica with the Princess Elisabeth Base, but most of all direct access to the bedrock, explains Thierry Camelbeeck, a seismologist at the Belgian Royal Observatory (ORB) and coordinator of GIANT-LISSA. This allows us to perform certain measurements which would otherwise have been far more difficult, or even impossible to realize. Firstly,

A changing continent

The Antarctic continent is deformed because of changes to the load applied on its surface. On the one hand, there is a slow deformation linked to the melting of the ice which happened at the end of the last ice age, or 10 000 years ago. On the other hand, the deformation generated by the current variations in the surface ice caused by global warming are not yet visible. To separate the two aspects of this distortion the researchers combine surface measurements of the distortion of the earth's crust (GPS) with measurements of gravity variations, which makes it possible to estimate the changes to masses with a precision of the order of one millimetre for the GPS and one billionth of a g (9.82 m/s^2) for gravity.

1 Installation of the seismometer into the borehole.
2 Lab container with the gravimeter inside.

we were able to install two ground positioning stations (GPS) in cooperation with the University of Luxembourg. These are used to track the movements of the base, or at least the rocky ridge of the Utsteinen Nunatak. These GPS's are of course connected to the global network and are expected to function all year round. During the first campaign, however, they were actually only in service for a little over a month. After that there were problems with the electricity supply. Apart from that, we were able to carry out absolute gravimetric measurements on the site during a subsequent field campaign. The intention is to repeat these measurements from one year to the next. Every other year, the Royal Observatory will send an absolute gravimeter there. The other years, the University of Luxembourg will deal with the equipment and the measurements.

By combining these dual data sets (absolute gravimetry and vertical movements of the site provided by the GPS) we can also gain information on the changes in the ice masses around the base. The changes to this gigantic mass, in a radius of the order of 250 kilometres around the base, also offer us a quantitative measure of the effect of climate change on the polar icecap. It should also be noted that the University of Luxembourg is performing the same kind of measurements in collaboration with the University of Colorado in Boulder (USA) in Greenland, which makes our measurements in Antarctica even more useful. But before we can draw any lessons from these data series and make comparisons with the northern hemisphere it is first necessary to build up observations for some ten years.

Our other major project in Antarctica concerns the installation of a broadband seismic station. This station is also intended to form part of the global seismic network. Since we are there on the bedrock, we have access to a whole series of very good quality seismological signals. The seismometer was installed during the 2009-2010 campaign. Unfortunately it was only possible to operate the equipment for one month, because of a lack of electricity. We hope that, starting from this Antarctic season, the base can operate continuously, including during the Antarctic winter, when the base is not inhabited.

The seismometer has been installed in a borehole. During its first month of operation it was in particular able to detect the major (8.8 magnitude) earthquake that affected the region of Concepcion in Chile. It is also worth mentioning that our instrument also provided measurements of the impact of windmills on the site. This tool also allowed us to collect some information on the surface seismology as well as tectonic seismic information. Finally, during the several weeks of working, the seismometer also detected some 'ice quakes' or shaking of ice plates.

The base should eventually tell us more about intraplate tectonics in Antarctica and the lithosphere structure just below the Belgian base. There is no doubt, since we are in an isolated region of Antarctica that this data will feed into and add to the global seismic monitoring network!

Antarctic Population

Antarctica has no permanent population. The continent's residents are researchers staying at winter or summer bases. The number of people carrying out or supporting research varies from around 4 000 in the summer to 1 000 in the winter.

The original inhabitants of the Antarctic

Scientists discover a cryoconite hole with a diameter of 5 metres near Utsteinen. Is there a big stone under the ice here?

Cyanobacteria or blue-green algae are among the oldest living organisms on Earth. In all likelihood they have been around for 3.5 billion years. They look like algae, but are actually bacteria that produce chlorophyll just like plants. The leading specialist in our country is Professor Annick Wilmotte of the University of Liège. She has been studying cyanobacteria for thirty years and in the last decade, she has concentrated her studies on the diversity of the cyanobacteria in the Antarctic.

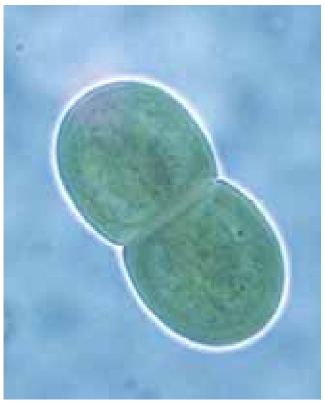
Only now are we realising how diverse the cyanobacteria are in the samples brought back from Antarctica.

Annick Wilmotte:
Cyanobacteria do indeed occur in fairly high numbers in the Antarctic. They flourish in extreme conditions. I wouldn't say they love the cold, but they put up with it. Thanks to their resistance they manage to colonise lots of environments on the Antarctic continent.

Until very recently, the distribution of cyanobacteria was not well studied. Before then, the only tool available to differentiate different species was the microscope, but thanks to new methods, such as DNA sequencing, we now have direct access to the genetic information. Only now are we realising how diverse the cyanobacteria are in the samples brought back from Antarctica.

The International Polar Year has involved more trips to the Antarctic than other years. More researchers have been on field trips. But we weren't waiting for the Polar Year to come around before entering into international collaborations. In 2003/4, for example, there was a British expedition to the Transantarctic Mountains. The expedition yielded samples from 82° South, which is very near the South Pole, and we characterised the cyanobacteria in those samples. That is fantastic! It seems that my 'little creatures' occur everywhere. The only condition being that a little liquid water be present, even if only briefly, at some period in the year.

Annick Wilmotte played an important role in the BELDIVA project, funded by BELSPO, which aims to map microbial diversity in the area around the Princess Elisabeth Base. She was among the first group of scientists to go to the Antarctic when the Belgian research station became operational in 2009 (along with two biologists from the University of Ghent, Karolien Peeters and Jeroen Van Wichelen, Cyrille D'Haese of the Museum in Paris and Steve Roberts of the British Antarctic Survey). The study was continued at the base in the next season by Zorigto Namsaraev, a young Russian in Annick Wilmotte's team from the University of Liège.



Zorigto Namsaraev:
I would call myself an extreme biologist. I am interested in extreme forms of bacterial life. I came into contact with Annick through a fellowship sponsored by BELSPO, and then I received a fellowship from the FRS-FNRS. I first went on expedition to Spitsbergen, in the North and then, in the International Polar Year, I went to Antarctica.

Annick Wilmotte:
I arrived at the Princess Elisabeth Base before the official opening. It was very interesting to see how the base was constructed. We were also able to talk to the technicians. It is really is a unique project. There is nowhere in the world like it. Utsteinen, the area around the base, is also extremely beautiful. A magnificent spot.

Zorigto Namsaraev:
What amazed me most was the technology. I should tell you that I come from Southern Siberia myself. Our winters can get as low as -55° Celsius. We know what it is like to live in such low temperatures. The station was designed to cope with extreme cold using new technologies: energy saving, the ultimate in insulation, alternative energy… very nice. Inside the base it was warm and comfortable. The only thing that bothered me is that the air was extremely dry. But that is normal: Antarctica is actually a desert. A cold desert. As there wasn't much room inside we slept in a tent.

Annick Wilmotte:
In 2010 you were able to take showers and wash your clothes in the base! None of that was possible when I was there! I arrived at the Princess Elisabeth Base in January 2009. An amazing amount of snow had just fallen. Two years before that, in January 2007, there had been an exploratory survey led by Damien Ertz, a biologist from the National Botanic Gardens. BELSPO had commissioned him to give a picture of the fauna and flora in the area around the future base. His report enables us to trace any changes that might occur later in the environment around the base. But I didn't recognise the landscape from his photos! It seemed like a completely different world. He had taken samples of the pebbles between the rocks. All I saw was the tops of huge boulders protruding above the snow. At first I couldn't find the markings that Damien had left on the ridge beside the base. He had such a good weather that he heard water flowing at the foot of Utsteinen! When I was there everything was stiff frozen. Just bad luck. It wasn't until seven days later,

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1 Cyanobacteria (blue algae) on the rocks near Utsteinen.
2 A miniature Perspex greenhouse increases the temperature inside by a few degrees.
3-4 *Cyanothece aeruginosa,* a blue algae found only on Antarctica.
5 Zorigto Namsaraev operates the ice drill
6 Where there is liquid water there is life. This is also true in Antarctica.

when the snow had to some extent blown away, that I was able to take samples from a few of the areas Damien had marked out. But, in the meantime, we had taken the opportunity to explore other interesting places in the broader environment.

Zorigto Namsaraev:
We had a tough schedule. Fortunately, conditions were better this time. One of the things I had brought with me was a fluorescence meter, an instrument we can use to check indirectly the efficiency of photosynthesis. It is very important to know: you might be looking at a dark patch on the rock, something organic, but you can't tell if it is dead or alive, unless you can measure whether it photosynthesises.

We wanted to know when our cyanobacteria were active. To find out, I marked out a number of sites with a small metal ring measuring 4 x 4 cm. Every three hours, day and night, I noted the temperature and light intensity and used the fluorescence meter to measure whether or not the organisms were active.

Annick Wilmotte:
That meant you had to leave your cosy sleeping bag every night to go lie on your tummy on the ice cold ridge!

Zorigto Namsaraev:
It was certainly worth the effort. We noted that the degree of activity is strongly related to the amount of sunlight. When the sun is low there is much less photosynthesis. An organism that ends up in the shade of a large boulder, for example, shuts down for a while and then starts again when the sun reappears.

We managed a few experiments using a sort of miniature Perspex greenhouse placed around the tip of the fluorescence meter. This protects the habitat from the wind, but not the sun. We can therefore increase the temperature by a few degrees and then use the fluorescence meter to see whether the level of activity changes. We want to know the temperature ranges within which cyanobacteria are active. Once we have the data, we can calculate how many days a year cyanobacteria can photosynthesise. With the artificial warming in the greenhouse we also aim to estimate how they would react to climate warming.

Annick Wilmotte:
Zorigto, and a Czech colleague, Josef Elster, have also drilled in cryoconites! These are holes containing liquid water. The name comes from kryos (ice) and konis (dust). It is a phenomenon you find in the Arctic and Antarctic (and the

The evolutionary history of the genes and the dating of fossils allow us to estimate when a particular species appeared: 150 000 or 500 000 years ago. Unfortunately, this is not possible for cyanobacteria and other bacteria. Their genetic material is more than 3 billion years old and fossils are an extreme rarity…

Alps). When a little stone is blown onto the ice by the wind, or gets there some other way, something peculiar happens: the ice reflects the rays of the sun but the stone does not. It absorbs the solar energy and heats up. The ice around the stone melts and the stone slowly sinks into it.

Zorigto Namsaraev:
It can happen quite quickly: I have seen a large stone disappear under the ice in a few days. It sank at about 1 cm a day. The process continues and the stone sinks as long as the sun's rays can reach it. The hole freezes over again at the surface, but you have liquid water above the stone, and that water may contain a microbial community. Cryoconites usually have a diameter of 10 to 50 cm, but I once found one that was 5 metres across. In the winter, the water will freeze, but in the summer, when the stone is again warmed by the sun, the water liquefies and the organisms become active again. If you put a sample from a cryoconite under the microscope, you will immediately see 2 or 3 different cyanobacterial species. The cryoconites near the Princess Elisabeth base were frozen on top, so we had to drill through the ice, which was a bit of a job.

Annick Wilmotte:
Our trips to Antarctica in the International Polar Year also gave us the chance to tackle an interesting scientific issue, i.e. are there any organisms on Antarctica that do not occur anywhere else?

Dutch Microbiologist Baas-Becking said in 1934, «Everything is everywhere, but the environment selects». If Baas-Becking was right, this means that organisms can appear anywhere provided the conditions are right. In the BELSPO AMBIO project we and our colleagues Anne Willems, Wim Wyverman and Elie Verleyen from Ghent tested this hypothesis by analysing the diversity and distribution of the microbes, microalgae and cyanobacteria in our samples. We know that Antarctic cyanobacteria can survive in higher temperatures. When we cultivated them in the laboratory they grow best at 15 or 20 °. They don't like the cold, but they put up with it.

Zorigto Namsaraev:
Cyanobacteria occur in all climates. There are many species that occur in Antarctica and in our own country. There are also species that only live in warm areas and therefore not in Antarctica. Yet, there are cyanobacteria that have been found only in Antarctica, such as *Cyanothece aeruginosa*. This was first found by a Norwegian in Dronning Maud Land, not too far from the Belgian base. DNA sequences from this species were later found in other places: including Alexander Island and the Ellsworth Mountains, but never outside Antarctica. This does not necessarily mean that it occurs nowhere else. It just may not have been found. But it seems at present that the species is endemic to Antarctica.

Annick Wilmotte:
If Antarctica has its own endemic species, we have to ask ourselves how they have survived. This is because the South Pole has had periods of total glaciation: i.e. when the ice was a kilometre thicker than it is now. Could the organisms remain frozen for thousands of years? Or were there places of refuge somewhere, retreats without ice, but with liquid water? Or nunataks that protruded above the ice?

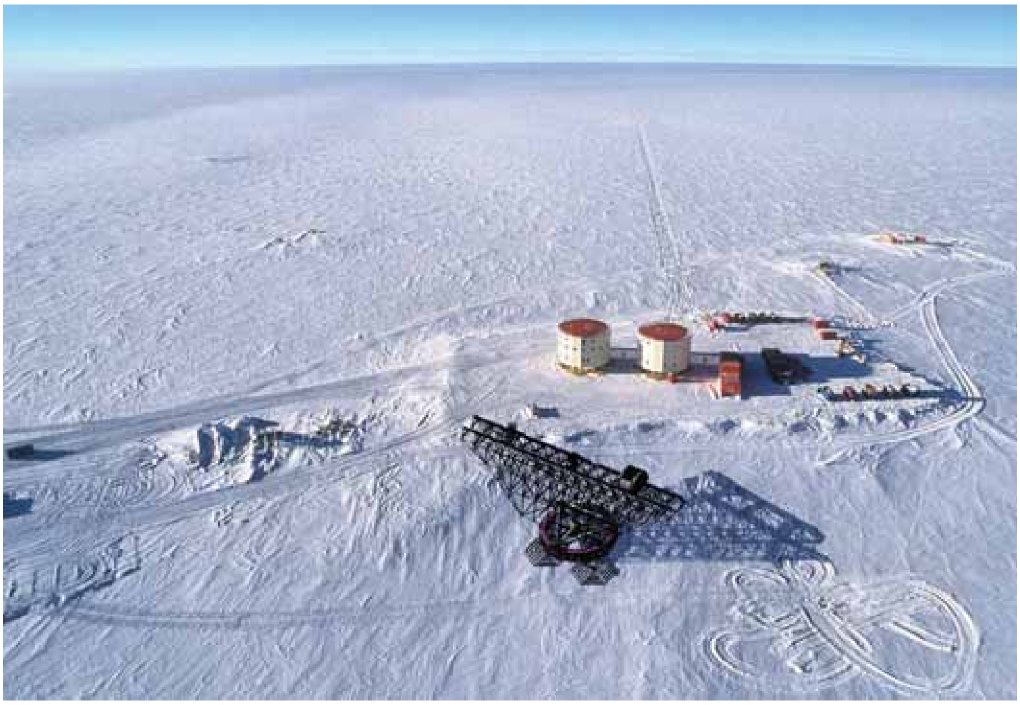
Maybe that biology can adjust the visions of the geologists and scientists developing glaciations models? You can infer the biological clocks for the evolution of many organisms. The evolutionary history of the genes and the dating of fossils allow us to estimate when a particular species appeared: 150 000 or 500 000 years ago. Unfortunately, this is not possible for cyanobacteria and other bacteria. Their genetic material is more than 3 billion years old and fossils are an extreme rarity…

1 Zorigto Namsaraev installs an air filter on the roof of the laboratory container near the base.
2 Josef Elster and Zorigto Namsaraev study a cryoconite.

The penguin

Penguins are birds that waddle around on land, but swim like fish in the water. They have plumage that looks like a tuxedo. They are found only in the Southern Hemisphere but are not confined to the cold areas. Although penguins cannot fly, they do belong to the bird family. There are 17 species of penguin, the smallest of which is the Little Penguin (Eudyptula minor). The biggest penguins are the King Penguin and Emperor Penguin.

A new european observatory at Dome C?



1 2 3

1-2-3
The astronomers are considering the construction of a new observatory a few dozen metres from the French-Italian research station Concordia at Dome C .

The White Continent is one of the coldest but also one of the driest places on Earth, two characteristics that are of great interest to astronomers. Even more so that the total absence of human activity (with a few exceptions) at those latitudes offers an extremely pure night sky with regards to atmospheric transparency and image quality, but also with respect to light pollution. Not to mention the polar night, which offers every year an uninterrupted observation period of three months.

European astronomers and engineers, along with their Australian colleagues, took advantage of the International Polar Year to work on evaluating the sites and astronomical instruments that would benefit from being erected in Antarctica, and especially on the Antarctic plateau near the French-Italian Concordia Base, at Dome C, which offers more advantages than just the pure sky and intense coldness. Dome C is located at high altitude. The Antarctic plateau reaches a height exceeding 3 000 meters, which protects the site from the intense katabatic winds, which roar down the icy slopes to the coast at speeds exceeding 300 km/h! In fact, Dome C has also been home to a scientific base since 2005 that has been in service for 365 days a year. This is an attractive site from an astronomical point of view, also for exploring the sky using new windows of the spectrum such as infrared and sub-millimeter.

Brought together within the European ARENA network (Antarctic Research: a European Network for astrophysics), some 100 engineers and astronomers therefore worked on characterising the site with a view to developing a possible future observatory as well as the kinds of instruments that might be installed there.

Professor Jean Surdej, from the Institute of Astrophysics and Geophysics of the University of Liège, participated in this initiative in the context of an interferometry project, which he co-chaired. A young researcher, Olivier Absil, and myself were particularly involved in working group 3 in this project, he says. This group dealt with interferometry in the visible and infra-red ranges. This concerned carrying out a pre-feasibility study for such a type of observatory. This type of so-called nulling interferometer was intended to detect and measure a type of radiation termed 'exo-zodiacal light.' By identifying nearby stars that are least affected by this radiation, astronomers can then study those which have exo-planets orbiting around them with a greater degree of certainty. Astronomers can then study the atmospheres of these exo-planets by means of spectroscopic analysis and possibly detect certain molecules that might reveal the presence of potential life forms.

The work done by the partners in this project resulted in the publication of a thick report in 2010, entitled 'Vision for European astronomy and astrophysics in Antarctica in the next decade.' This report concludes that it would be worth installing an astronomical observatory in Dome C, including a nulling interferometer in the visible and infra-red spectral ranges.

4-5-6
The Concordia station is situated on the Antarctic plateau, at an altitude of more than 3 000 metres and a distance of one thousand kilometres from the French coastal station, Dumont D'Urville.

4

5

6

What sort of astronomy in Antarctica?

In addition to the ARENA initiative, which brings together 22 partners and whose final report is intended for national research agencies and the European Commission, this consortium has also developed an information site for the general public on the issues and attractions of astronomy in Antarctica. One feature of this site which bears the name 'ARENA Public outreach' is that it was installed and is managed by Anna Pospieszalska from the University of Liège. Here you will find in particular information on the most recent developments in astrophysics in Antarctica, such as adaptive optics, interferometry, coronagraphy, and of course infrared and submillimetric imaging, a whole panoply of techniques that allow astronomers to observe the formation of stars, their evolution and death, to measure their pulsations, to detect planets outside the solar system and to trace the first moments of the universe.

http://www.arena.ulg.ac.be/

Antarctica
Marine biodiversity

12 000
years under the ice

In the southern summer of 2002 a disaster of untold proportions took place in the Antarctic. It started on 31 January. Satellite images revealed huge cracks in the Larsen B ice shelf on the east of the Antarctic Peninsula. Larsen B was a 220-metre thick floating ice shelf. It was eaten away from underneath by the warming currents of the Southern Ocean. From the top, summer melt water had penetrated to the heart of the ice mass through old glacial fissures.

> *Large areas that were covered with ice for thousands of years suddenly became ice-free. This gave rise to new habitats and new types of seabed creature communities.*

Scientists watched on in astonishment as the entire ice shelf collapsed, broke apart and finally melted into the sea in the space of just 5 weeks. Larsen B was not the first ice shelf to collapse. In 1995 the nearby Larsen A shelf disappeared, but it was much smaller and nowhere near as old. This time the area of ice measured 3 250 km^2. The Larsen B shelf had been stable for 12 000 years, since the last Ice Age. An event like this had never been seen before.

The disappearance of the Larsen B ice shelf is an unmistakable sign that something serious is happening to our climate. But it opens possibilities for us to further our knowledge too.

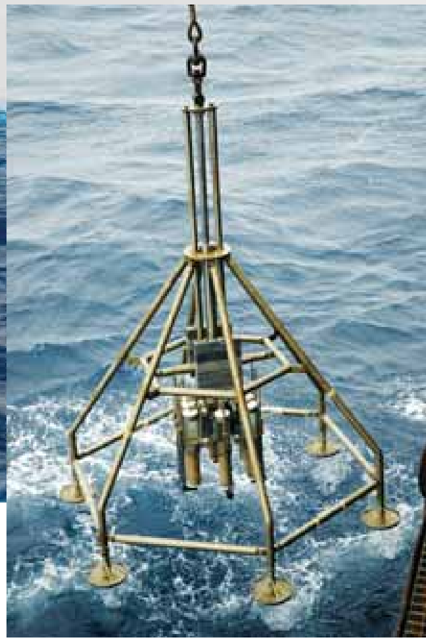
The seabed beneath the Larsen ice shelf has lain hidden for 12 000 years. No light, no plankton at the surface, no nutrients… What does the seabed under the ice look like? Is it a lifeless desert, or not entirely…?

This is a unique opportunity for science.

Researchers from around the world are watching on with anticipation at what will happen in the years to come: how quickly will the newly opened area be colonised by animal and plant species?

A team of marine biologists from the University of Ghent is playing a special role in this study. They have sailed to Antarctica aboard the German icebreaker, the Polarstern, to collect samples from the seabed that lay beneath the Larsen B ice shelf for thousands of years.

Ann Vanreusel:
We assumed that there would be hardly any life in the seabed there. This is because life depends on the nutrients produced in the top layers of the water column, through photosynthesis, under the influence of sunlight. We expected to see the first steps of a colonisation process. The Larsen B shelf disappeared in 2002. In 2005, when we went to look for the first time, the area had been ice-free for three years. That was quite exciting.



1 The German research vessel RV Polarstern belonging to the Alfred Wegener Institute - an icebreaker used in Arctic and Antarctic waters.

2 A multicorer allows to take samples from the seabed at great depths.

3 The plastic sample tubes are filled with sediment and ocean water from the deep sea.

The disappearance of the icecap allowed us to go looking for new habitats: areas that differ from the rest of the ocean floor because different chemical or physical conditions exist there.

How come you went with a German expedition?

Marine research in the Antarctic is always an international affair. We can't stay at the Princess Elisabeth Station. It's too far from the sea. And Belgium doesn't have an icebreaker. So the best way is by international cooperation. We've been collaborating with the people from the Alfred Wegener Institute in Bremerhaven from the very start.

We are one of the few research groups in the world to be looking at the meiofauna component. Meiofauna are small ground-living animals, organisms you can only see with a microscope. We sieve the sediment we are studying: anything that passes through a 1 mm sieve but sticks in a 30 micrometer sieve falls within our research domain. Of course, this is a technical definition, but not a coincidental one, because it is relevant ecologically.

Jeroen Ingels:
We are welcome in an international team of this type because we work in a particular niche. Our contribution is thought important. It complements the work of the German researchers. This is why we are almost always asked to come and join these expeditions.

Why are the meiofauna you are studying important?

Jeroen Ingels:
Well, diversity is extremely high in this group. It is a significant component of the benthos, i.e. the group of organisms living in the seabed. Not only because of the quantity of species, but the density too: there are a great many. One of the questions we are asking ourselves relates to the role of these meiofauna in the food chain. For the time being, we are assuming that they play an intermediary role: the link between primary production and its decomposition.

Ann Vanreusel:
What we mean by primary production is phytoplankton. A food web almost always starts with plant growth. They trap light energy to produce

Samples from the seabed are taken for processing in the ship's laboratory.

carbon through photosynthesis. This is what plants do on land. In the sea, it is done through microscopically small algae, which are a major producer of food.

The next step in the food chain, for example, are krill, small shellfish that feed on the phytoplankton. These are the first consumers. The krill are then grazed by sea mammals, fish and so on.

The benthos are a little more complicated: they are creatures that live in the seabed. They depend on what is happening up at the surface. Some of the nutrients produced at the surface sink to the bottom where they are remineralised. They decompose and nutrients are again released, the nutrients needed to enable the algae to bloom again.

The algae at the top of the water column need more than just solar energy. To grow they need nutrients such as minerals, phosphates and nitrates. Benthos are active in the decomposition process. In this sense they are an important component of the food web.

At a particular location, that once lay below the Larsen ice shelf, it was noted that the seabed was covered with typical bacteria. These organisms are not dependant on plant growth and solar energy: they can use chemical energy to make carbon compounds. They have no need of sunlight. Therefore, they have been able to develop under the ice shelf.

Have you found life on the seabed that was there all the time, in the dark, under the Larsen B ice shelf?

Ann Vanreusel:
The first expedition to the area returned with photographs indicating that there are sources of methane in the seabed. The presence of methane gas leads to the existence of very specific communities: this is because some bacteria can utilise chemical energy. These are organisms that are not dependant on plant growth and solar energy: they can use chemical energy to make carbon compounds. They have no need of sunlight. Therefore, they have been able to develop under the ice shelf.

At a particular location, that once lay below the Larsen ice shelf, it was noted that the seabed was covered with bacteria typical of this type. This is known as a chemosynthetic system: a community that does not use photosynthesis to produce nutrients but uses chemical energy to fix carbon.

We only saw photos taken by underwater robots: we could see entire mats of these organisms, but, unfortunately, the robots were not equipped to take samples. This is why the Polarstern returned in 2005 with the right equipment and one of us on board to take samples across the area as a whole and these locations in particular.

The material has been processed now. We actually did discover unique communities with an extremely high density of meiofauna. The highest numbers are not at the surface, but deeper in the sediment. However, diversity is low. It is actually a single species that has colonised the sediment in very large numbers. But we have made a strange observation: the creatures are not feeding on the chemosynthetic nutrients! It was a species typically found near a methane source. We can use biomarkers to see what the creatures feed on: chemosynthetic or photosynthetic nutrients. And it appears that they don't use chemical energy, but nutrients derived from photosynthetic energy.

Do they appear to have changed diets?

Ann Vanreusel:
That is difficult to say. The observations are unique. We have found a system unparalleled in other marine habitats. We have found an impoverished community with a very high density. This is typical of a situation in which lots of food is suddenly available. A fast increase of one dominant species. But we don't really know where the food is coming from. The photosynthetic energy we find there is still extremely limited, because the area only recently came free of ice. There still isn't much food in circulation. We actually suspect that it might be a sort of transitional system: that chemosynthetic energy used to be there, but was no longer available in recent times. We haven't got to the bottom of it yet, but the most important message is that radical new processes are taking place.

Large areas that were covered with ice for thousands of years suddenly became ice-free. This gave rise to new habitats and new types of seabed creature communities. It is a hotly topical subject. We are facing huge changes, but we can't continually observe these changes.

The last data are from 2007. However new samples were collected in February 2011. These samples are being processed now and they should give us new information on the evolution of the marine ecosystem after the collapse of the iceshelf. In this way we have access to unique material for comparison to investigate the temporal changes in order to reconstruct the impact of climate change.

1

2

1 Jeroen Ingels (left) processes the fresh samples. The climate room is kept at a low temperature (0-4° Celsius) to minimise disturbance.

2 *Halomonhystera* sp., a species of nematode (roundworm), which occurs in vast numbers in the sediment in the Larsen area east of the Antarctic Peninsula.

The Royal Meteorological institute monitors the atmosphere above Utsteinen

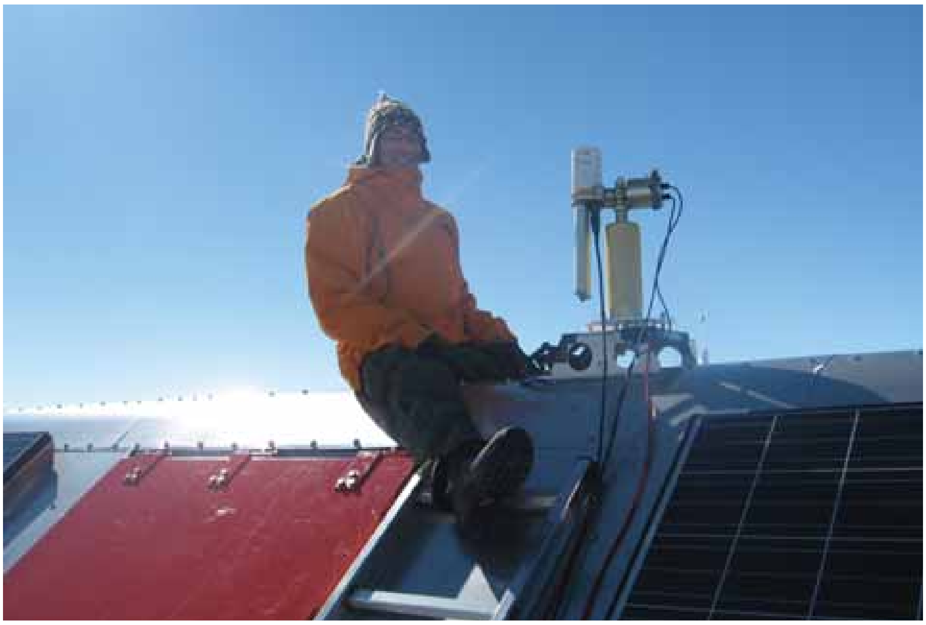
During the BELARE 2008-2009 expedition, when the Princess Elisabeth Base was still under construction in Antarctica, a member of the Royal Meteorological Institute (RMI), Alexander Mangold, from the Institute's 'Observations' section, went to the spot in order to deploy two measuring instruments in the context of the BELATMOS project. This project, financed by BELSPO, is aimed at setting up a long-term network to monitor the chemical composition and fine particles in the Antarctic atmosphere, while at the same time measuring ultraviolet radiation at ground level.

During this first mission we installed two instruments for studying the atmosphere and aerosols, explains Alexander Mangold. This concerned a solar photometer and an aethalometer. The aethalometer makes it possible to determine the concentration of soot, the 'black carbon' in the atmosphere. This is an instrument which pumps in external air and passes it over a filter, which then gradually turns black. An optical system then analyses this blackening, which is then interpreted by the system's computer. This gives us an idea of local soot concentrations. This type of instrument in general measures the concentration of carbon particles in the air derived from wood, hydrocarbon products, etc. We have discovered that the Antarctic air at Utsteinen, where the Belgian research station has been set up, is particularly 'clean,' at least if you believe the first measurements.

Another instrument, the photometer, for its part measures the attenuation of solar radiation in the entirety of the atmospheric column on seven wavelengths, says the researcher. This gives us information on the quantity of aerosols present in the atmosphere. The photometer which we have at our disposal also tells us about the level of pollution in the atmosphere as well as the nature of the most prevalent aerosols.

But scientific adventures in Antarctica do not always run without a hitch. We installed and started up these two instruments during the 2009 campaign. These provided interesting initial results. However, these tools did not function continuously, contrary to our hopes. And with good reason, because the station could not provide us with electricity all the year round to ensure that we could collect data in the winter. That said, this would not have been useful as regards the solar photometer. The sun doesn't shine for several months at a time at these latitudes. It is difficult under such conditions to measure any aerosol whatsoever on the basis of the attenuation of light! On the other hand, this could have helped the aethalometer.

As an extension of this first mission, Alexander Mangold returned to the Belgian Antarctic base during the most recent (southern) summer. The idea was to restart a series of measurements and to run the aethalometer continuously throughout the year. We also took advantage of this new mission to install two additional instruments. These are a spectrophotometer intended to measure the development of the entire ozone amount in the atmosphere and the intensity of the ultraviolet radiation at ground level, and a TEOM (Tapered Element Oscillating Microbalance), an instrument which measures the concentration of the mass of aerosols and molecules floating in the atmosphere. This involves an instrument of the same type as those we use here, especially in Belgium, to detect concentrations of fine particles in the air that we breathe. And just like the aethalometer, the TEOM should function continuously throughout the year, he concludes.

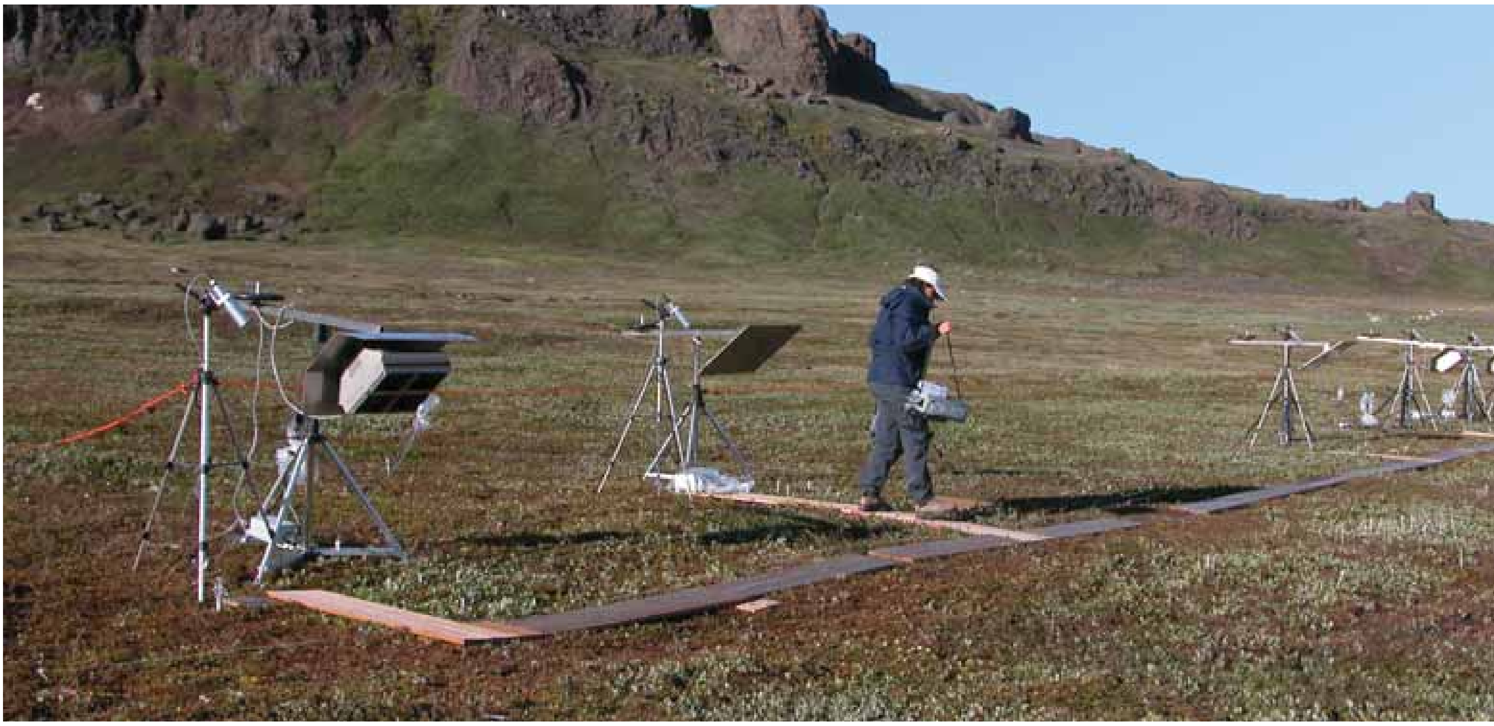


1 Alexander Mangold and the sunphotometer.
2 Spectrophotometer.
3 TEOM instrument

The polar bear

The polar or white bear is found only in the northern polar region, where its white coat makes it perfectly camouflaged. Reaching up to 3 metres in length and weighing up to 800 kg it is the largest of the Ursidae family. The polar bear has no natural enemies apart from man. The polar bear is an exceptionally good swimmer and is sometimes seen a few kilometres off the coast. The name Ursus maritimus means 'sea bear'. It also hunts on land, where it is exceptionally quick. Polar bears can travel up to twenty kilometres a day and they follow the edge of the pack ice, which is further north in the summer than in the winter. The polar bear preys mostly on seal but will sometimes take other animals such as the arctic hare, the beluga whale, etc.

Belgian heatwave in greenland

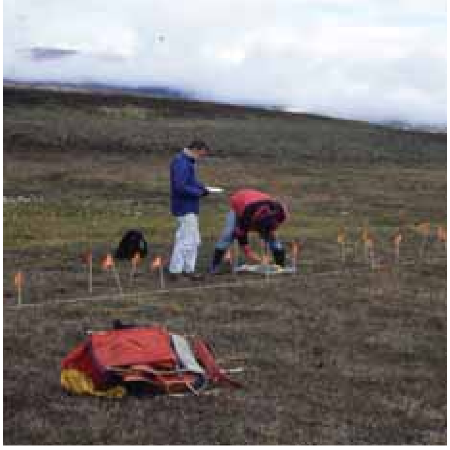


What will happen to life if the climate changes? How are ecosystems responding to rising temperatures? At the start of the International Polar Year scientists set themselves the challenge of answering these questions by carrying out specific experiments at the North and South Poles. One of the pioneers of these warming experiments is professor Louis Beyens of the University of Antwerpen. Most of his research is done at the North Pole.

Louis Beyens:
Thanks to research collaborations with colleagues from other countries we were able to set up our first warming experiments in the late 90s at the Zackenberg Research Station on the northern coast of Greenland. We conducted these together with Prof. Ivan Nijs also from the University of Antwerp. It was particularly interesting to be able to study the effects of a single phenomenon – the warming of a predefined area of land, for example – on a variety of organisms. Later, we carried out similar experiments on the west coast of Greenland, on Qeqertarsuaq (Disko Island). I always ask myself a very simple question: what lives where, and why?

The first time I ever visited the Pole was in 1978. I was part of an expedition of mountain climbers. I arrived in Greenland, where you can see rocky pinnacles protruding from the ice at the edge of the ice sheet. I asked myself what might be living on those mountaintops.

For a long time it had been assumed that in the ice ages everything was covered with a thick layer of ice and that this had swept all living creatures away, leaving a blank sheet.



1 2

1 Warming experiment conducted by the University of Antwerp in Qeqertarsuaq, Greenland.
2 The demarcated areas are heated using infrared lamps.

But, later, we were forced to change that picture to some extent. When ice flows along the side of a mountain we find traces of it afterwards: striae. Glaciers carry stones and boulders with them and wear scratches in the rock. This enables you to see how high the ice came during the ice ages. It turns out that some mountaintops were never covered in ice: not even in the North, during the Ice Age. This immediately set us wondering whether we might discover something that has survived the Ice Age on those mountaintops. Naturally, I wanted to go and take a look for myself.

I realised soon enough that we know hardly anything at all about the taxonomy, the classification and evolutionary history of the single cell organisms I study. In that period, the late 70s, early 80s, science was dominated by molecular biology. Back then, my question of 'what grows where?' sounded almost old-fashioned. Today we know it as 'biodiversity'.

The warming experiments you carried out are very topical, given the present climate issue…

Of course, global warming is partly responsible for that, but they have a broader significance too. I'm thinking back to the ice ages: we had a similar period at the end of the Ice Age. The Ice Age actually came to an end through a series of shocks. It wasn't a gradual rise in temperature. About 15 000 to 11 500 years ago, a period known as the Late Glacial, we had a period of warming, followed by cooling, then warming… and then quite considerable cooling. Only after that did we experience the final warming that heralded the beginning of our present period. This is extremely interesting: how fast were those changes? An isotopic analysis of ice cores from Greenland now reveals that this cooling was exceptionally fast at some points. There were dramatic fluctuations in the climate.

Did it take place over centuries?

No, it took place over tens of years. Temperature fluctuations of 5 degrees Celsius for sure… that is enormous. We want to know how organisms that live in a cold ecosystem react to warming. Naturally, this slots in easily with the current warming issue that we are all familiar with.

Can these species survive a warmer climate?

When it comes to the plants typical of the tundra, like lichens and grasses, we know that habitats will shrink in a warmer climate. We are already seeing the tree line moving northwards, making the polar region smaller.

And what is the situation with single cell organisms in the polar region?

Of course, we are not studying all single cell organisms, that is beyond our remit. We are concentrating on two groups in particular. In the laboratory we are primarily concerned with a group of shelled amoebae, known as testate amoebae. There are naked amoebae too, but amoebae with shells are an interesting group, because their shells can be located even after the organism has died. They leave fossils behind.

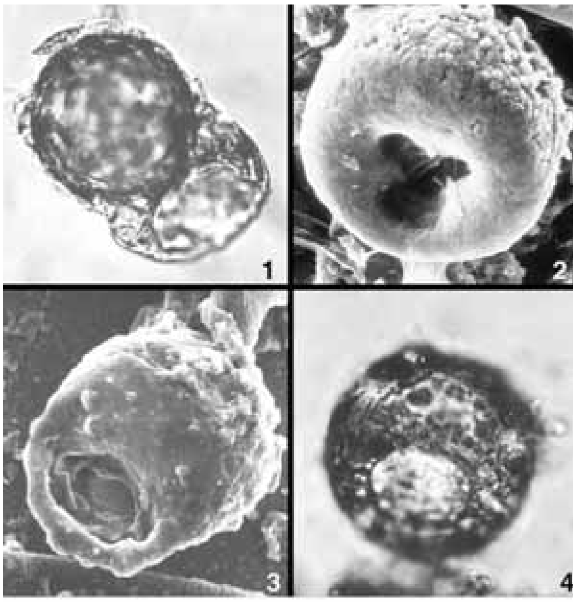
We are looking into what happens in these communities when the temperature changes. We call them 'communities' because they exist as different species with differing numbers or populations. Do the same species stay important as you warm? Do some species disappear? What characteristics determine whether a given species will respond to warming in one way or another?

We created a heat wave in the area, for example! To do that, you have to know what actually constitutes a heat wave in Greenland. It is not easy, because a lack of measurements means we don't know what kinds of temperatures may once have reigned there. So, we have to extrapolate. Luckily, we had access to data from the Arctic weather station in West Greenland, where the Danes have been taking measurements since the early 20th century.

How warm it gets varies greatly from region to region; in southern Greenland top temperatures of 22 degrees Celsius have actually been measured. But they are exceptional. Maximum temperatures are lower at other Greenland locations. At the second site of the experiments, on Disko Island, there was a 12-day period when the average temperature exceeded 9 °C. That can be considered as a heat wave.

For our experiment we put another few degrees on top, just to be sure of the effect. We warm a predetermined area of the ground with infrared bulbs. Naturally, this area is packed with sensors and thermometers that feed data through to the computers continuously. You can also do the experiment by specifying, for example, that there should always be a difference of + 5 ° with the outside temperature.

And then you watch what happens. Single cell organisms have a short generation time: they divide into two about once every ten days to give a new generation, depending on species and conditions.



Thecamoeben, amoebae with shell

When is an experiment a success?

When something happens! When change is observed in the communities. It is really exciting. Seeing nothing happen may be an equally important observation, but, of course, it's not as thrilling.

Can any conclusions be drawn yet?

We are still processing the data from 8 different replications in Greenland. It is not always easy to interpret. We observed that there are indeed changes when the temperature rises: some species become more important, others less so, but we have also noted that in many cases this is just a temporary phenomenon. In other words: the system can restore itself when you return to the original situation. This is extremely important: it means that the system has a certain elasticity to it. We call this 'resilience'.

The results of our experiments are not always straightforward: besides warming there are other factors that play a huge role, such as the dampness of the soil. As the researcher you decide whether to add to water to the experiment. Does the soil dry when the climate warms, or do you get more precipitation too? On the world-scale it can have far-reaching consequences for the food supply.

Does this study give a better understanding of the effects of climate change?

That's beyond our reference framework, but I think we are providing important pieces to the puzzle, albeit indirectly.

Single cell organisms account for a large portion of the biomass in the soil. If something goes wrong there it can have huge consequences for higher organisms, plants and anything that feeds on plants….. That is why I always get a little annoyed when the media focus on something as iconic as the polar bear! Of course, a symbol makes it easier if you want to discuss the consequences of climate change, and you are hardly likely to opt for a single cell organism. You can't see them without a microscope and they are not very cuddly. Polar bears have much greater appeal. But they are not a very good example. Single cell organisms are the base of the foodchain. Take them away, and your whole system collapses. Not if you take away the polar bear. In Spitsbergen they recently found the jaw of a polar bear that has been dated at about 130 000 years old. This means that as a species the polar bear survived the last interglacial period, from 125 000 to 100 000 years ago.

The new factor in it all, of course, is man. The toxic substances we produce in the south are transported through air and water and end up in the North Pole region. Here they accumulate in the food chain and are ultimately found in their highest concentrations in the top predator, the polar bear.

Antarctica
Marine biodiversity

BIANZO II : Studying the benthos and its dynamics to foresee the future of marine biodiversity

The Belgian BIANZO II programme (Biodiversity of three representative groups of the Antarctic Zoobenthos – Coping with Change), which officially ended in 2010, was a significant project of the International Polar Year.

By studying certain aspects of the ocean life, in particular life on the sea bed (benthic communities), the partners in this project (the Universities of Ghent, Liège, Brussels (ULB) and Burgundy (France), and the Royal Belgian Institute of Natural Sciences), supported by BELSPO through its SSD (Science for a Sustainable Development) programme, sought to answer several questions regarding the current situation and the dynamics and future of southern marine biodiversity. This study concentrated more specifically on three groups of denizens of the depths: nematodes, amphipods and echinoids.

This programme was not only a Belgian contribution to the exploration of diversity via its first section known as NOWBIO, says Dr De Broyer, but also a study of the dynamics of benthic populations via the DYNABIO section. In this second part of the project, researchers focused on such varied questions as: why are such species to be found in certain places and not in others; what food sources do they rely on, what are their ecological needs, etc.

The third part of the project was more prospective. With FOREBIO, the teams attempted to set up various simulations, models intended to determine the manner in which certain communities can develop in relation to the climate changes affecting the planet. The questions that guided the work in the third section of BIANZO II concerned the potential impact of environmental changes

on the three target groups being studied, but also, by extension, other species, as well as benthic marine biodiversity as a whole. In short, this involved an experiment-based conceptual approach.

Note: The final BIANZO II report is available on line at:
www.belspo.be/belspo/ssd/science/Reports/BIANZO_FinRep_phase1.pdf

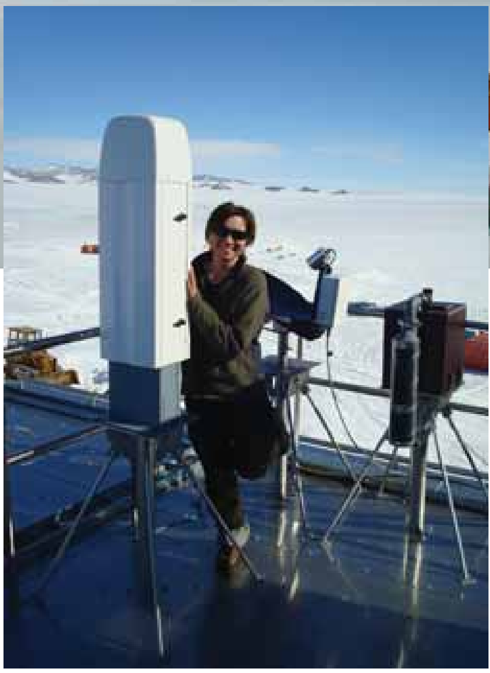
1 *Epimeria rubrieques*
2 Setup of acoustic traps.
3 Echinoidea.
4 Nematoda.

Low clouds over Utsteinen

Antarctica is covered with a 2 200 m thick ice pack (average thickness, with a maximum of 4 800m). The sheet was formed through the compaction of snow over millions of years. The icecap contains so much water that the sea level would rise by 62 metres if the Antarctic ice were to melt (the Greenland ice sheet contains enough water to add another six metres to the sea level). If that were to happen many of the most populous areas of the Earth would become uninhabitable: large areas of Belgium and the Netherlands, for example, not to mention countries like Bangladesh and the islands of the Pacific. It looks very much like the plot for a disaster movie.

However, the IPCC, the International Panel on Climate Change, can to some extent put our minds to rest: even if the warming of the Earth were to continue unabated it would take until the year 4 000 for the ice at the South Pole to disappear. That is a long way off. Antarctica is barely thawing at all: the average temperature on the coast (the Antarctic Peninsula aside) is still always ten degrees below zero in the summer. The Antarctic ice sheet is shrinking because the ice around the edges of the continent calves off and floats away as icebergs. And…there are indications that in recent decades Antarctic glaciers have been moving more rapidly and transporting more ice to the sea. Glaciologists (some of whom are from Belgium) are trying to work out how much ice is lost in this way and how quickly the sea level will rise as a result.

However…ice isn't just being lost. It is being added too. As the Antarctic Ocean gets warmer the air becomes more humid. And this damp air is carrying more snow to the South Pole than before. But how much snow falls in Antarctica and is the greater supply enough to offset the ice calvings on the coast? Is the sea level rising and if so, how quickly? Scientists



have been looking for the answers to these questions for quite some time.

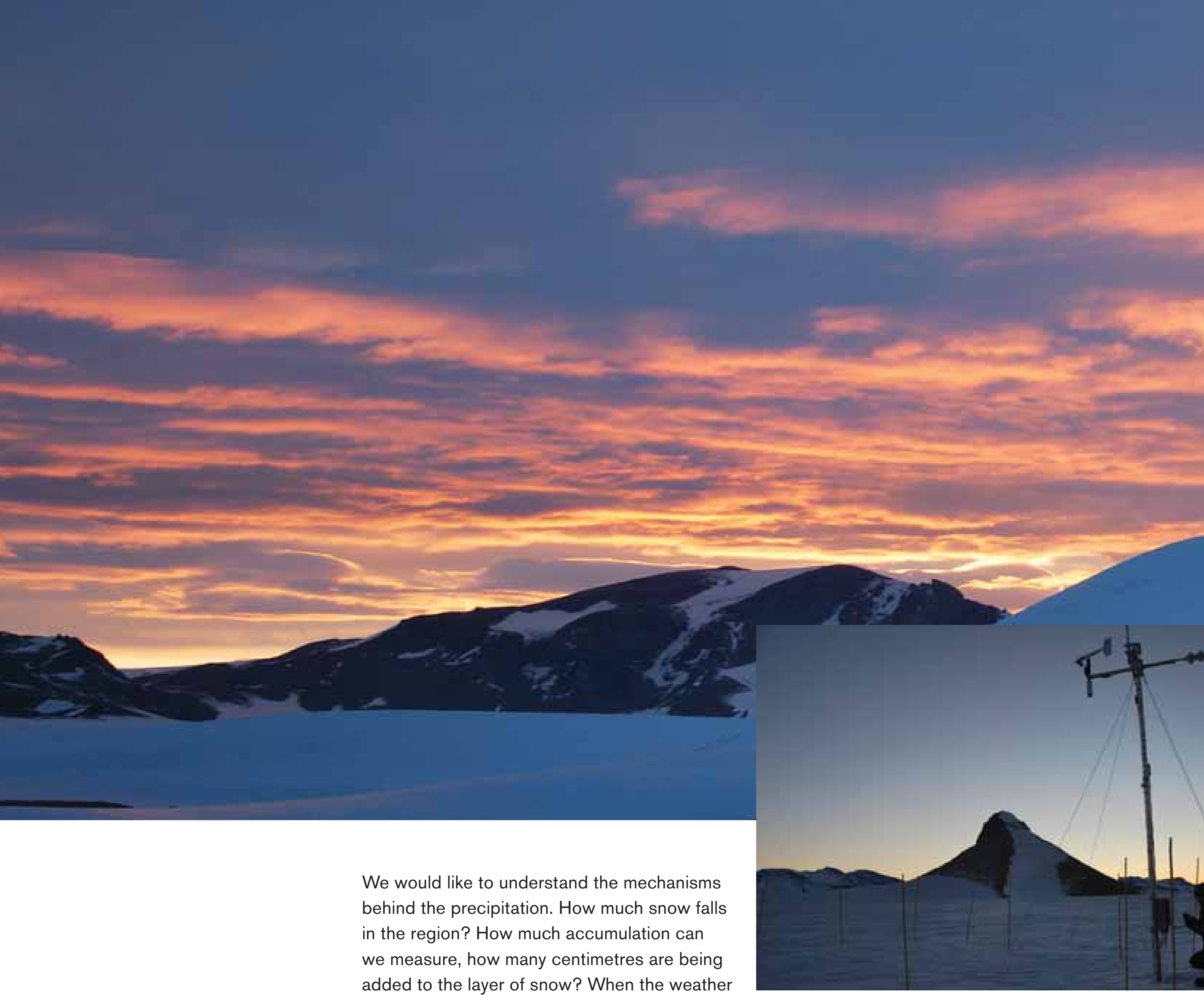
KU Leuven (professor Nicole Van Lipzig) sent a young researcher to Antarctica to gather data on the clouds that are transporting this damp, snow-laden air to the Southern Continent.

Irina Gorodetskaya:
I was working for the Glaciology Laboratory in Grenoble, France, when I heard of Nicole Van Lipzig's project through a visiting Dutch lecturer. It was the very problem with which I had been wrestling. I was working on mathematical models for atmospheric interaction, of the type that could also be used in IPCC reports. There was an urgent need for data to validate these models. At the time there was a great deal of discussion about the interaction of sea ice and cloud formation at the North Pole. Recent observations on the ground appeared to be entirely inconsistent with what the models were forecasting. To check the mathematical model for the Antarctic all I had at my disposal was data from two observation stations: the Franco-Italian Dome C on the high plateau and the American Amundsen-Scott base on the South Pole itself. KU-Leuven's proposal to go and measure clouds near the Princess Elisabeth Station was a great stroke of luck!

What did you think of the Princess Elisabeth Station?

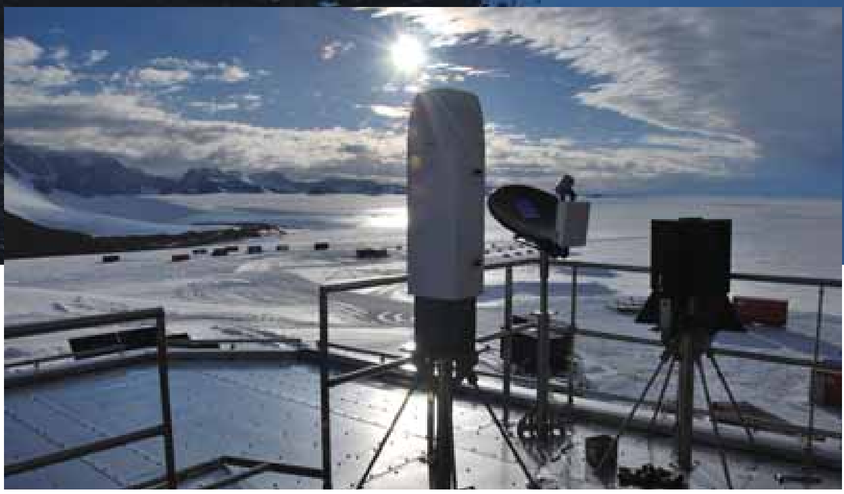
Impressive! We arrived in February 2009. It is a unique concept. Its aerodynamic shape is very striking. The site has been well thought out too. It is a special place, extremely beautiful. It was a pleasure to work there. The Belgian base was ideally located for our research: neither on the coast nor on the high plateau. Utsteinen lies at the foot of the Sør Rondane mountain range.

1 Tent camp at Utsteinen.
2 Irina Gorodetskaya beside the ceilometer and other instruments on the roof of the station.



We would like to understand the mechanisms behind the precipitation. How much snow falls in the region? How much accumulation can we measure, how many centimetres are being added to the layer of snow? When the weather is bad in Antarctica it snows. This bad weather is caused by cyclones that circle the Southern Continent and penetrate to the interior. The Princess Elisabeth Base lies right beside an area of high cyclonal activity. Though the cyclones do not move right across the continent, they do affect the interior to some extent. The base is right in the area where the warm damp air passes over the coast. Not only that, but it sits right on the edge of the mountain range. The topography of the area forces the air to rise sharply. The journey from the coast to the Princess Elisabeth Station is uphill for the first 110 km, then it is almost level, and near the base it suddenly rises steeply. Here there is precipitation, because the air has to rise, and in so doing it cools and is no longer able to hold the moisture it brought with it from the ocean surface: it snows. This region, about 100 km from the coast, has the highest precipitation in the whole of the Antarctic (Antarctic Peninsula aside).

The mountains on the other side protect us from the katabatic winds: cold winds that sweep down from the high plateau. These winds are extremely powerful: they average 20 metres a second over the year. That is an enormous amount. It is often these winds that make it so difficult to live and work in the Antarctic. But we were safe from them at the Princess Elisabeth Base. When the wind comes down from the high plateau it is cold and fierce and clings to the surface. The mountains halt it. Air circulation from the coast fills the troposphere, does not cling to the surface and is not, therefore, halted by the mountains. The katabatic winds have a relatively small effect at the Princess Elisabeth Base and this allows us to concentrate on the influence of the cyclonal winds that come in from the coast. An excellent place to try to gain an understanding of the precipitation patterns.



1 The automatic weather station at Utsteinen.
2 From left to right: the ceilometer, the cloud radar and the infrared-pyrometer.
3 Besides temperature, air pressure, wind speed and wind direction, the automatic weather station records snow accumulation. A sensor (right) measures the distance to the snow surface.

You have installed an automatic weather station at the base.

Yes - we installed the weather station in February 2009. It gives us hourly averages of not only basic weather parameters (temperature, humidity, wind) but also radiative fluxes (solar radiation reaching the surface and reflected, and also radiation emitted by the snow surface and by the atmosphere), changes in the snow height, and snow temperature profile. We need all these measurements to understand processes related to the surface mass and energy budgets.

We also had two instruments for measuring clouds. The first we call the ceilometer. It is a sort of laser that measures the height of the cloud sheet. Laser signals bounce back from small particles in the cloud, droplets, ice crystals or snowflakes… so we can see what the cloud is made of. The other instrument is the infrared pyrometer. This instrument is passive. It emits nothing, but measures the heat radiation from the atmosphere. This tells us the temperature of the cloud base.

In the January/February 2010 observation period we mostly saw clouds at medium height: 3 to 4 km. And we know that these clouds had a temperature of -35 °C on average. This is the sort of information that these instruments will tell you.

In storm conditions the cloud cover is lower. We had more low clouds from a height of 500 metres to 1 km. These clouds only occurred during stormy weather. When we saw low-lying clouds we were able to predict with great accuracy that a storm was on its way. From observations at other stations we also know that there is a direct link. The low clouds are also much warmer: the average temperature rose appreciably from –35 to –5°C. That is the highest cloud temperature we measured. The low-lying warm clouds also have a greenhouse effect: they absorb heat radiation from the ground and return it to the ground. We were able to see the effect immediately via the automatic weather station, which measures radiation flux: during a storm there was an increase in the heat radiation directed towards to the ground by the atmosphere.

A storm of this type makes itself felt throughout the tropospheric air. The ground cools dramatically during a cold period. The temperature on the ground is lower than in the higher air layers. We call this inversion. There is no exchange of energy between air layers. The surface is insulated from the atmosphere. This is typical of cold periods in Antarctica. But a storm messes everything up. The temperature rises. Turbulence is no longer under control. Air layers intermix and the inversion disappears. The temperature near the surface rises quickly, by 20 to 30 degrees, and snow falls.

We had snow at the Princess Elisabeth Base during cold periods too, but that was to do with redistribution.

This is the typical phenomenon known as snowdrift: no fresh snow falls, but snow is blown around by the wind. Fresh snow falls with every storm.

Did you come across anything unexpected?

Yes indeed. We had no data at all on this area. It is a strip of more than 1 000 km of Antarctic land at which, until recently, no measurements have ever been taken. We had nothing on the land between the Japanese Syowa and the Russian Novolazarevskaya stations. We don't really have a clear understanding of the snow accumulation processes in this area. We know that most of the snow is brought here over the sea by the cyclones, yet there is very little snow accumulation to be seen. How come? It is still a bit of a puzzle. The various snow accumulation models give a large spread of results in this region. We just don't know which model is correct because we don't have enough observational data.

We now have two years worth of meteorological data from the Princess Elisabeth Base and we are seeing snow accumulation differ drastically between the first and second years! In the first year of observations an additional 70cm of snow fell. In the second, almost none. What can we learn from the measurements of temperature, wind speed, humidity, cloud height and so on? It seems that there were many more storms in the first year, with higher wind speeds and more snow during the storms. In the second year there were fewer storms with lower wind speeds on average. We also saw that the snow that fell during the storm was later blown away. Some may also have disappeared through sublimation: snow can evaporate without thawing first.

We are now looking forward with great anticipation to what will happen in the third year of observations. I am now in the process of analysing the storms of 2009: what was it about those storms that caused the unusual increase in snow? We know that in the rest of this area of East Antarctica, i.e. the whole of Dronning Maudland, the snowfall was normal that year. I would like to understand what happened specifically in the area around Utsteinen and how it fits in with the mathematical model. It would be really interesting to see whether we get more than the average snow accumulation in 2011 and whether we get more cyclonal activity due to the global warming of the climate.

How does global warming affect this system?

There have been publications since the last IPCC report showing that the increased precipitation in the Antarctic is strongly related to the condition of the sea ice. Less sea ice means more open water and more moisture in the air. The increase in average temperatures could mean more water vapour available to account for the greater precipitation in Antarctica, provided there are cyclones to carry the damp air to the continent. We cannot say with any certainty whether there might be more cyclones.

Has the International Polar Year yielded anything for climatology in the Polar regions?

A lot of work was done to consolidate our existing knowledge and share it with others. And that is a good thing. Including data from previous expeditions. Countries have all too often carried out their research in isolation in the past. Countless Russian expeditions have gone ahead in the past, with fantastic results, but well… Few new research projects have been started. A few projects were abandoned at the last minute and that probably had a lot to do with the financial crisis. But one of the IPY's important objectives, i.e. international cooperation and data exchange, has been a success.

Do you get measurement data in from the station all year round or only in the Antarctic summer season?

The idea is to monitor winter and summer data from the station, even if it is not manned. Meteorological data from the automated weather station have been sent to Belgium without interruption since its installation in 2009 through an ARGOS satellite beacon. Almost in real time: the figures appear on our computer screens barely six hours after the measurements have been taken. We are therefore able to analyse and monitor them remotely. When we come onto the base in the Antarctic summer we can also collect the data stored in the memory of the automated weather station for verification.

The cloud measurement instruments should also give a continuous feed of information but they don't have a battery. They are connected to the power supply at the Princess Elisabeth station. We may have tried to move too quickly: we had wanted to be there the first year the station became operational. But, of course, an experimental polar station like this, which has to run on renewable energy, won't yet be up to the mark. The power system wasn't ready for use. In the Antarctic summer of 2010 we were able to take all the measurements we wanted with the cloud measurement instruments and precipitation radar we had brought with us. I had made all the preparations to send the data through via a laptop in the winter, when the base is unmanned. I was able to check all the instruments, download data and take measurements from my office in Leuven, via the server. Everything was working brilliantly… until the power went down at some time in March.

1 GPS measurements in the field.
2 Ice crystals.

We had no data at all on this area. It is a strip of more than 1 000 km of Antarctic land at which, until recently, no measurements have ever been taken. We know that most of the snow is brought here over the sea by the cyclones, yet there is very little snow accumulation to be seen. How come? It is still a bit of a puzzle.

A breakdown?

No. A lull. Princess Elisabeth is a zero emission station. We depend on nature for our energy. In the winter there is no sun, so no photovoltaic power, and then, if the wind stops blowing for a week or two, and no power comes in from the wind generators, the batteries can go flat. Normally, the generators would take over, but they failed to do so because of a technical defect. The power went into safety mode, and that means that the first team to land in Antarctica in the new season will have to start the power up by hand.

Were you terribly disappointed?

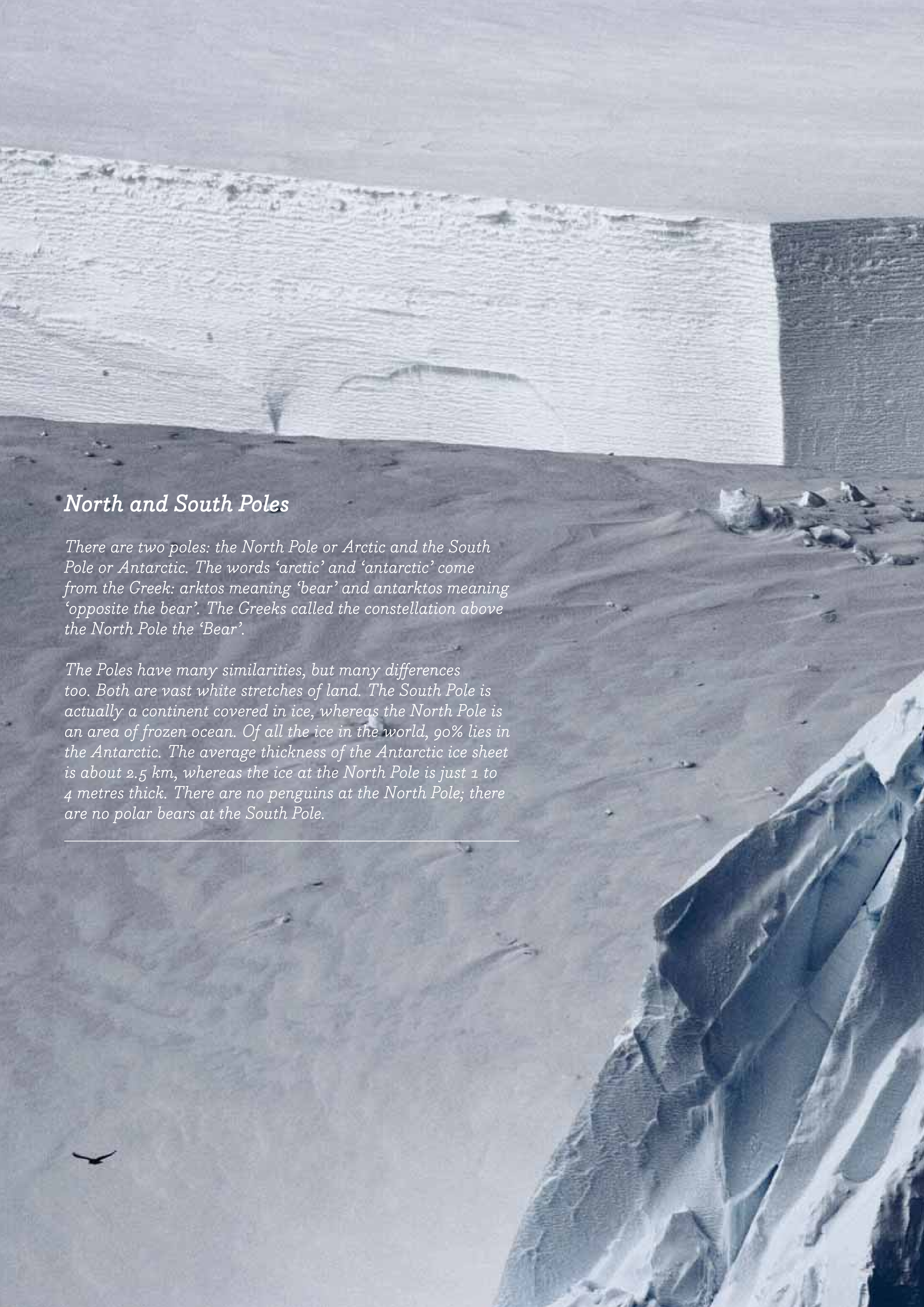
Well, of course, we wanted to collect as much data on as many storms as possible. Last winter we only managed to measure two. But when you are working in extreme conditions, in an inhospitable place like the Antarctic, you can't expect everything to go perfectly to plan. We, scientists that is, have to test things out and try to set our instruments and see our programme through, just as the station operator and his staff have a thousand and one problems to solve. We are all in it together. This is why it is so important that we work as a team and communicate with each other openly, so that everyone is in a position to make the right decisions for his project.

The Antarctic ice sheet contains 90% of the fresh water on the planet.

Conclusion by Nicole van Lipzig

The IPY has given climate research in Antarctica a significant boost. The 'traditional' story is that air carries more moisture when it is warm and that this is why more snow will fall in Antarctica in a warmer world. However, recent studies show that the anticipated increase in snowfall is yet to occur despite the warming of the atmosphere. We are also seeing a huge variation in total snowfall in the Antarctic from month to month (differences up to as much as 25%). This all tends to indicate that not just temperature, but beyond that air currents, are of the utmost importance when it comes to the amount of snow falling in Antarctica. This is not great news: since no increase in snowfall is being observed it looks as though the Antarctic ice sheets are beginning to lose mass through the more frequent ice calvings at the edges. This subject is still a matter of debate among groups using satellite observations, so the picture is not yet entirely clear. It is important that we study the processes that underpin the relationship between air current, cloud formation and snowfall, and so gain a better understanding of how the system works. Only in this way can we improve our models and refine our climate projections for the future. We hope to contribute in this area with our own observatory.

Since no increase in snowfall is being observed it looks as though the Antarctic ice sheets are beginning to lose mass through the more frequent ice calvings at the edges.

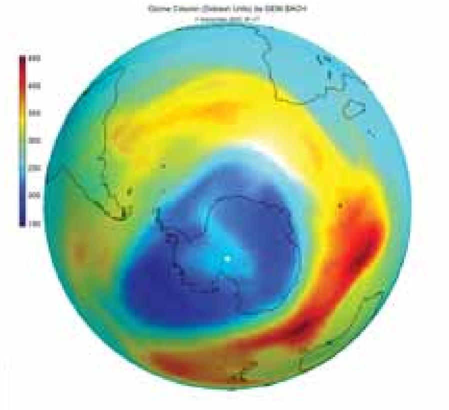


North and South Poles

There are two poles: the North Pole or Arctic and the South Pole or Antarctic. The words 'arctic' and 'antarctic' come from the Greek: arktos meaning 'bear' and antarktos meaning 'opposite the bear'. The Greeks called the constellation above the North Pole the 'Bear'.

The Poles have many similarities, but many differences too. Both are vast white stretches of land. The South Pole is actually a continent covered in ice, whereas the North Pole is an area of frozen ocean. Of all the ice in the world, 90% lies in the Antarctic. The average thickness of the Antarctic ice sheet is about 2.5 km, whereas the ice at the North Pole is just 1 to 4 metres thick. There are no penguins at the North Pole; there are no polar bears at the South Pole.

GEM-BACH and modelling the 'chemical' weather



Ozone column (Dobson units)
by GEM-BACH
2 September 2003, 6 UT

The Belgian Institute for Space Aeronomy (IASB), in collaboration with the Canadian ministry for environment (Environment Canada), benefited from the international polar year to test and validate a weather prediction system which includes the chemical composition of the atmosphere. Two chemical components particularly interested the scientists: stratospheric ozone and nitrogen oxide.

As regards our contribution to this project, this concerned the integration of chemical models from the BASCOE chemical model into the Canadian GEM weather forecasting system, says Simon Chabrillat from the Belgian Institute for Space Aeronomy. This resulted in the combined GEM-BACH model, which in the framework of the International Polar Year delivered between 2007 and 2009 forecasts of the dynamical and chemical state of the stratosphere – especially at polar latitudes. These results were successfully compared with measurements taken on the field during the summer 2007 at the Eureka station in Nunavut (Canada).

This global model went into operation starting from the international polar year. It has also been installed at the IASB and operates thanks to the supercomputer at the Space Pole at Uccle. This tool now makes it easier for Belgian researchers to monitor the chemical composition of the stratosphere on a global scale, with very high resolution and virtually in real time (BACCHUS project).

Polar puzzles

The Federal Government commissioned the IPF (International Polar Foundation) to design and build the Princess Elisabeth Station in the Antarctic. Construction started in November 2007 and the base was officially inaugurated on 14 February 2009.

The construction of the Princess Elisabeth Station was an enormous achievement. Although, strictly speaking, the new research station is not a scientific project, the Princess Elisabeth is our country's most palpable contribution to the International Polar Year. It was the choice of renewable energy in particular, for a base that would operate without CO_2 emissions, that generated the keen international interest. The Belgian base is generally seen as an example for the future.

The Princess Elisabeth Station is a showcase for the IPF. A demonstration of sustainable technology. If we can use wind and solar power to survive the harshest climate on Earth, we can do it anywhere. The IPF is a foundation for public advancement that sets itself the objective of conveying to the General Public the complexities of climate change in a clear manner. In this, the role of the Polar Regions and scientific polar research have a special place. The IPF is convinced that individuals, organisations and corporations can be helped to choose a responsible, sustainable lifestyle through awareness-raising.

1 Puzzle pieces making up the North Pole region.
2 Sandra Vanhove (IPF) with youngsters solving the puzzle.

Sandra Vanhove is head of the IPF's educational team:
Since the inauguration of the prefabricated Princess Elisabeth station in Tour § Taxis in the summer of 2007 we have received a deluge of specific questions from schools, policy makers and the media. The interest in the Poles and in its research is enormous. So, to satisfy demand, we have been travelling around with our three-dimensional Polar Puzzles. We have 2 models of about 1 metre in diameter, one of the North Pole and the other of the South Pole, which can be completely dismantled. The idea is to draw a clear distinction between the North and South Poles, the pack ice and the icecap; so they show the underlying continent of Antarctica, the mountains protruding above the ice sheet and the ocean under the pack ice at the North Pole. You can also apply models to these Polar puzzles to forecast the consequences of global warming. (http:/www.educapoles.org/nl/project_detail poolpuzzel).

Carrying on from the Polar Puzzles, we started the Class Zero Emission project on the IPF's premises here in Anderlecht, with support from the Flemish and French-speaking ministers for education. This is an interactive show for youngsters between 10 and 18, in which feel, play, investigation and debate are central. By experimenting independently, students learn about the interdisciplinary nature of polar and climate research and are encouraged to think about the broader context of a low carbon society. Students on teacher training are also given a specially adapted show. Teachers too can learn more at special workshops. (http://www.educapoles.org/nl/projects/project_detail/klas_zero_emissie/)

The IPF was also an official partner in the DAMOCLES project (Developing Arctic Modelling and Observing Capabilities for Long-term Environmental Studies). This is a 4-year European research project looking into the interactions between the pack ice, the sea and the atmosphere in the North Pole region. It involves more than 200 scientists from 11 countries. The IPF took care of the outreach part, to deal with communication for the General Public. A travelling exhibition was set up and this was launched in Belgium,

INTERNATIONAL POLAR FOUNDATION

1 A workshop for teachers during the IPY congress in Oslo.
2 How do you explain the albedo effect?

1 2

EducaPoles
The educational website of the International Polar Foundation

www.educapoles.org

after which it could be seen in a number of European countries, including Bulgaria, Luxemburg, Italy and France.

The IPF has also been involved in many other projects in the IPY. It produced the only official IPY documentary, entitled 'Beyond the Poles', for the World Meteorological Organization (WMO) and the International Council for Science (ICSU). The documentary explains several polar research projects.

One IPF worker, Jean de Pomereu, joined a Chinese Polar Expedition (Chinare) aboard the icebreaker Xue-Long and wrote up a report of this on the IPF website, SciencePoles.

The IPF contributed to an online interactive programme for schools around the world, entitled Polar Weeks, in the run-up to the IPY closing conference in Oslo in 2010 and the publication of the Polar Resource Book, a series of class activities and educational initiatives on the Poles intended for interested parties in and outside education.

The International Polar Year closed with a large scientific conference in the Norwegian capital of Oslo from 6 to 12 June 2010, attended by more than 1 000 scientists from 60 countries. Parallel educational sessions were organised alongside multidisciplinary sessions in which reports were given of the results of the Polar Year and the impact of changes underway in the Polar Regions. Sandra Vanhove sat on the steering committee responsible for the outreach and educational programme on behalf of the IPF.

We organised six sessions each with its own theme based on the classroom, the General Public, the museums, the media, etc. There were also 4 themed workshops involving experiments and lectures especially for teachers. We invited 120 teachers to Oslo. There were many more candidates, but we could only offer travel and accommodation for 120 people. We had to be extremely selective. Three of these teachers were Belgians. In exchange for attending the conference free of charge, teachers told us how they approach the subject of the Poles and the issue of climate change in the classroom.

Now that the Princess Elisabeth base is up and running the Polar Foundation intends to set up a new, large-scale project, the Polaris Climate Change Observatory. This will be a large, permanent exhibition at several locations across the world to raise public awareness of the role of the Poles as well as the causes and effects of climate change.

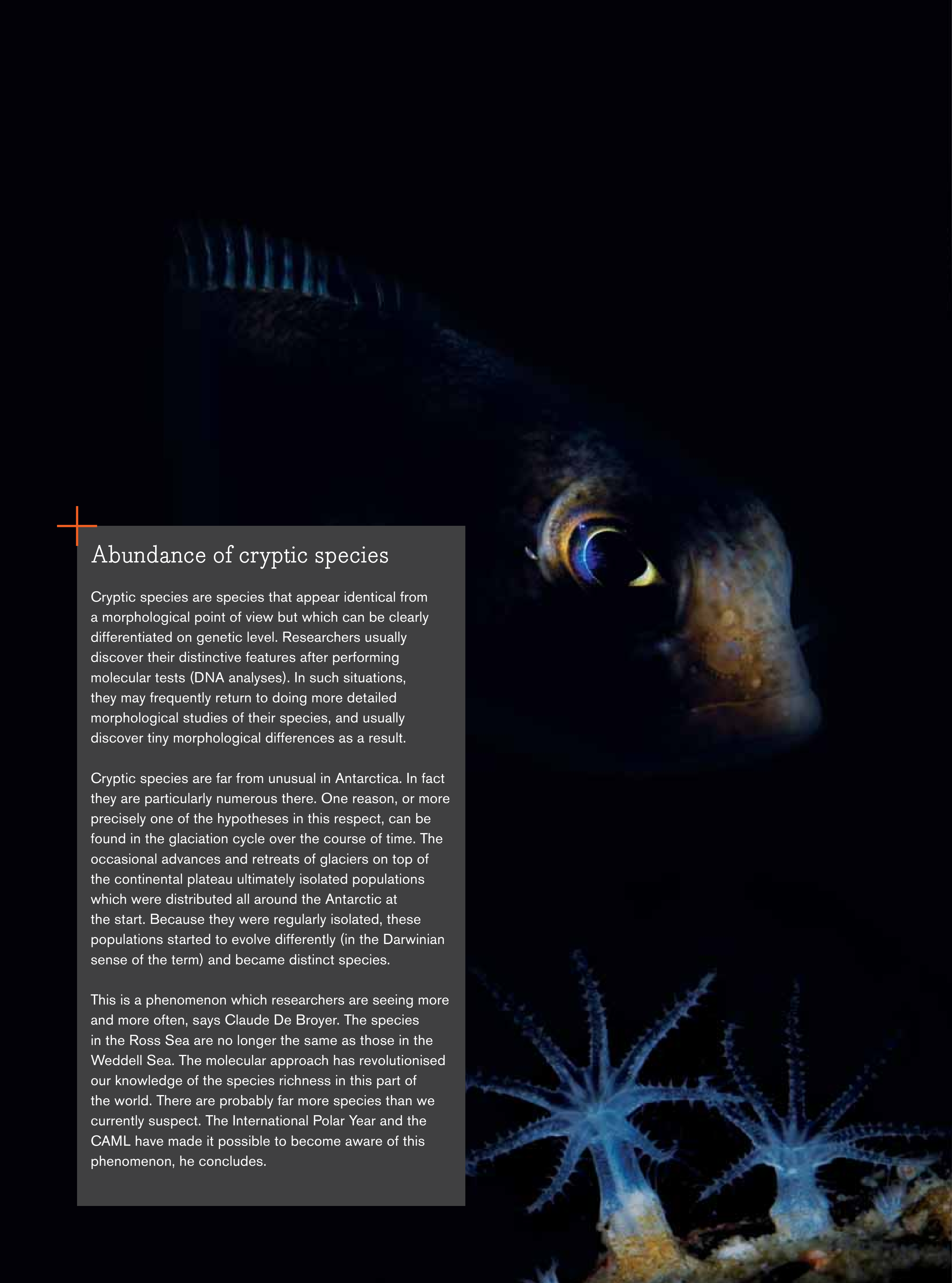
ANDEEP: Fishing for miracles in the deep seas bordering the Antarctic

The ANDEEP project (acronym of ANtarctic benthic DEEP-sea biodiversity: colonisation history and recent community patterns) was run under the aegis of the CAML (Census of Antarctic Marine Life) and the International Polar Year. This is despite the fact that it was launched in 2002. This project, with the participation of Belgian researchers (C. De Broyer, B. Danis, P. Dauby, P. Martin, F. Nyssen and H. Robert of the Royal Institute of Natural Sciences, as well as A. Vanreusel, I. De Mesel, K. Guilini and J. Ingels of the Universiteit Gent) aimed to explore the extreme depths of the seas and oceans on the edges of the Antarctic continent.

Abyssal research is fascinating, comments Claude De Broyer. But it's also very expensive. Which explains why it was difficult to get this project going. In the end, thanks to the German Alfred Wegener Institute, it was possible to carry out four exploration campaigns in the extreme depths of the oceans using their oceanographic vessel, the Polarstern. The most recent campaign – ANDEEP-SYSTCO – was run during the southern summer in 2007-2008. Each campaign lasted ten weeks. This allowed us to explore the abyssal depths down to 5 600 metres in the Atlantic zone of the Southern Ocean, which is the usual operational area of the Polarstern.

The results are fantastic at the biodiversity level, enthuses the Belgian researcher. 90% of the species we collected, were previously unknown. There are hundreds of them! In particular crustaceans. A German team from the University of Hamburg which specialises in isopods (woodlice, for example, are isopods) has collected some 600 new species. As for us, we have laid our hands on 200 unknown species of amphipods. Some have already been described, while others have not. And there are more than just these two groups of animals. The abyssal depths have also provided large numbers of sponges, sea stars and fish that are waiting to receive a name. We knew we would discover unknown species, but not in such quantities. It was absolutely incredible!

These specimens have now been distributed among the different laboratories involved in this research. Nevertheless, most of the collections are being managed in Hamburg. It will take years of work for specialists to identify each specimen from these miraculous fishing expeditions. It is first necessary to check in the literature whether the individual under the microscope hasn't been described yet. Next specimens have to be studied, compared, described, drawn, photographed, and so on. The morphological description of these new species, the taxonomical work, is the basis of all future scientific work, says De Broyer, without forgetting that today this basic work is supplemented by other kinds of information, especially genetic.



Abundance of cryptic species

Cryptic species are species that appear identical from a morphological point of view but which can be clearly differentiated on genetic level. Researchers usually discover their distinctive features after performing molecular tests (DNA analyses). In such situations, they may frequently return to doing more detailed morphological studies of their species, and usually discover tiny morphological differences as a result.

Cryptic species are far from unusual in Antarctica. In fact they are particularly numerous there. One reason, or more precisely one of the hypotheses in this respect, can be found in the glaciation cycle over the course of time. The occasional advances and retreats of glaciers on top of the continental plateau ultimately isolated populations which were distributed all around the Antarctic at the start. Because they were regularly isolated, these populations started to evolve differently (in the Darwinian sense of the term) and became distinct species.

This is a phenomenon which researchers are seeing more and more often, says Claude De Broyer. The species in the Ross Sea are no longer the same as those in the Weddell Sea. The molecular approach has revolutionised our knowledge of the species richness in this part of the world. There are probably far more species than we currently suspect. The International Polar Year and the CAML have made it possible to become aware of this phenomenon, he concludes.

Antarctica
Climatology

Can iron save the world?

The Antarctic ocean CO_2 pump

During the International Polar Year the German research vessel Polarstern set off for the Antarctic Ocean with fifteen tons of iron sulphate on board for a remarkable experiment. The scientists on board wanted to ‘fertilise’ the ocean with iron to induce an algal bloom. This was not their first attempt: a similar experiment had been carried out in the Antarctic summer of 2003/2004. The idea is simple: iron stimulates algae to bloom. Algae on the ocean surface absorb CO_2 (carbon) from the atmosphere and transport it to the deep sea. The greater the algal bloom the greater the quantities of this greenhouse gas stored in the ocean. Iron as a way of fighting global warming.

The iron fertilisation experiment was controversial. Environmental organisations protested and even confronted the German government: isn’t it dangerous to interfere with nature on a large scale? But the scientists aboard the Polarstern finally got the green light to press ahead with their attempt to increase carbon absorption in the Antarctic Ocean.

Scientists from our country also had firsthand experience of those fertilisation experiments. Professor Frank Dehairs of the Vrije Universiteit Brussel was involved in the fertilisation experiments aboard the Polarstern in 2004, collaborating with colleagues from Alfred Wegener Institute, Germany.

Frank Dehairs:
Our group played a modest part in that experiment. We had implemented a technique used to measure carbon transport, so our expertise was very welcome aboard.

The Antarctic Ocean is an important mechanism in climate regulation via the biological carbon pump. The ocean contains about 65 times more CO_2 than the atmosphere. That is an enormous amount. It can be increased a little more, but there is a limit.

How does the system work? The plant-like organisms at the surface, phytoplankton, fix carbon from the air through photosynthesis. In one litre of water this is just a small quantity, but extend it to the millions of cubic kilometres in the ocean and it is, of course, gigantic. We are occupied with the question of what happens to that carbon once it has been absorbed by the biomass. Some of it gradually makes its way into the food chain and some of it sinks into the deeper ocean.

Scientists aboard the French research ship Marion Dufresne II.

The Antarctic Ocean is an important mechanism in climate regulation via the biological carbon pump. The ocean contains about 65 times more CO_2 than the atmosphere. That is an enormous amount. It can be increased a little more, but there is a limit.

Imagine the ocean as a huge mass of water in which organic particles are forever raining down from the surface ocean. Only a small fraction of this accumulates in the sediments while most of it is respired back to CO_2 by bacteria. We investigate the factors determining this carbon flux, how much carbon is stored in the deep sea, and what the regional variability of this process is.

Not only does phytoplankton need light and nutrients such as carbon, nitrogen and phosphorus to grow, but it also needs trace elements and iron in particular. And there's the rub: There is a lot of iron on land. It is one of the most common elements on the earth. But there is precious little of it in the sea.

The so-called fertilisation experiments are an attempt to do something about this.

How does iron get to the ocean naturally?

Dust! Through the erosion of continents. Through the air. But it can also travel in the other direction: resuspension of iron-rich particles from the seafloor.

The problem is that iron is as good as insoluble. Dissolved iron occurs in extremely small concentrations, since it oxidises easily to precipitate in the form of iron hydroxides. The latter are not readily available to the algae.

So fertilisation seems like a good idea?

Let's be careful. We are on thin ice here. By adding iron we are hoping to increase biomass by increasing the activity of the plankton. But the fundamental question is this: what happens to that biomass? If it doesn't sink to the deep ocean you won't have achieved anything. This is because any organic material that remains at the surface will be decomposed through the action of bacteria and will be released again as CO_2, which finally escapes back to the atmosphere. The CO_2 you have captured is released a few weeks later and everything will have been in vain. But, if you manage to store the CO_2 in biomass that sinks out to really deep in the ocean, you have done well. The CO_2 greenhouse gas will have been safely stored for a few centuries. This is the point of the fertilisation experiments.

Safety drill: Frank Dehairs helps a colleague into her life jacket.

But, if you manage to store the CO_2 in biomass that sinks out to really deep in the ocean, you have done well. The CO_2 greenhouse gas will have been safely stored for a few centuries. This is the point of the fertilisation experiments.

Did it work?

When you spread iron across the ocean, phytoplankton grows more vigorously. This you can clearly observe. The thing to remember is that most of the iron simply sinks out of the surface waters and is not available for plant growth. But the small portion that dissolves in the water does stimulate growth. Diatoms are a major component of phytoplankton in the Southern Ocean. They have a skeleton composed of silicon oxide and of course also fix carbon through the process of photosynthesis. By investigating the evolution of both, the silicate concentration and the silicon isotopic composition over time, one of our researchers has witnessed a significantly enhanced consumption of silicate by diatoms following the action of fertilisation with iron. So it is clear that iron stimulates biomass growth, but the question also is what happens then? How much of this biomass will sink out of the surface ocean?

We study this by investigating the upper water column activity of natural thorium 234 relative to the activity of its parent isotope uranium 238. Thorium is a naturally radioactive element that attaches very easily to small particles floating around in the water, including particles of biological origin. When these particles sink to the bottom they take the thorium with them. As a result, the water at the surface contains less thorium than it did before. Under normal conditions thorium is in balance with uranium 238 uranium. If the thorium-234/uranium-238 ratio falls below 1, we know that particles have been exported out of the surface waters to the bottom. We measure this, and combined with knowledge about the ratio of carbon to thorium in the sinking particles, we can calculate the quantity of carbon that has sunk to the bottom. This is the carbon flux we are looking for.

In the experiment we carried out aboard Polarstern we witnessed a biomass increase over about 30 days. This was followed by a huge increase in the carbon flux out of the surface waters. So, biomass gradually developed and then sunk quickly to the deep ocean. After 5 or 6 days everything was gone.

So was it a success?

Yes…! (laughs), but that doesn't mean I am all for large-scale fertilisation. A cost-benefit analysis soon reveals the nonsense of it. And you still have to calculate how many tons of iron it will take to get a ton of carbon on the seabed. Then you would have to keep it up

permanently, spreading iron over the sea from hundreds of ships at the same time, because the effect disappears very quickly. Ships that are already emitting CO_2 anyway!

This really isn't the way to fight global warming, even though there are groups who argue the case, because there is a lot of money to be made out of it, of course. Just imagine the ecological cost. You want to send a mass of organic material into the depths of the ocean, but the system contains only a limited quantity of oxygen. There is a chemical limit on how much oxygen can dissolve in water. This oxygen is removed as a result of the partial oxidation of organic carbon particles raining from the surface ocean to the seabed. These deep waters take centuries to come to the surface and reabsorb oxygen.

You are actually quite sceptical…

I think it is dangerous to take these large-scale actions without knowing the long-term effects. The experiment we were involved in was quite limited in scale. Only a few tens of tons were spread over an area of around 100 km in diameter. The ship stayed there for a month. The effect quickly disappeared. This is very different from fertilising the entire Antarctic Ocean. It is of course of scientific interest to investigate what happens when action of this type is taken, but it is dangerous to extrapolate it to industrial applications.

And now what?

The fertilisation experiments continue, but other research groups have focused their attention on places where iron enters the system naturally. In the Southern Ocean these are mostly areas along the sub-Antarctic islands, because there are shallows there, continental shelves stretching a few hundred metres below the surface. Natural fertilisation occurs here through erosion of the islands or via upwelling of iron-rich sediment particles caused by ocean currents.

We have fantastic satellite pictures of the Kerguelen Archipelago and Crozet Island where algae bloom every spring. They are carried along into the open ocean. These blooms die out in winter and reappear the next spring. These are some of the most fertile areas of the Southern Ocean. The penguins know this. The plankton attracts fish and the penguins come after these. Although satellite images are excellent for providing a global overview we still need to go at sea to observe the processes that are going on. Indeed, if you want to find anything out about the water column at 1 000 or 3 000 metres, you have to go out there with your sampling equipment. But the satellite tells us where to take the ship.

You have to be aboard a ship like the Polarstern for your research?

Yes, but Germany is not the only country with which we collaborate. We also have fruitful collaborations with colleagues in Australia, France and the US. Scientific research is not possible without international collaboration. But it's not a one-way traffic: other countries are interested in our expertise since it provides access to specific results which are crucial for the whole of the project. So in the end it's a bit about give and take.

In 2008, during the International Polar Year, I joined the BONUS – GoodHope expedition aboard the Marion Dufresne II, from the Cape of Good Hope to the Wedell Gyre, the huge gyre current south

1 Scientists from the ULB in the Belgica laboratory container aboard the Australian research vessel Aurora Australis in 2007. They are wearing special suits to prevent sample contamination.
2 Bad weather in the Southern Ocean
3 The Benthic lander is lowered: the Perspex tubes are pushed carefully into the seabed to take the sediment samples.
4 CTD rosette sampler. This system is used to take water samples at selected depths.

of 58° S in the Atlantic sector. The objective was to take a strong team of physicists from the Université de Bretagne Occidentale and the Institut Européen de la Mer (Brest) to look at the return flow of the conveyor belt, the global circulation of warm surface water and cold deep-sea water, of which the Gulf Stream is part. The deep-sea water that flows from the Atlantic Ocean to the Indian and Pacific Oceans returns as surface water. At the Cape of Good Hope you have the well-known Agulhas Retroflexion current, where turbulence and enormous eddies churn the water over. We contributed to evaluating the impact these peculiar physical conditions have on the biochemistry, and in particular the carbon fluxes, in the area.

Have any conclusions been reached?

Yes indeed. The sea looks uniform, but it is certainly not homogenous. There are huge zonal differences in productivity and in the transport of carbon. We are starting to get a clear picture now: the area where most of the carbon is absorbed lies between the sub-Antarctic and Polar Front where the surface ocean shows a large temperature gradient. Productivity is generally high in that area.

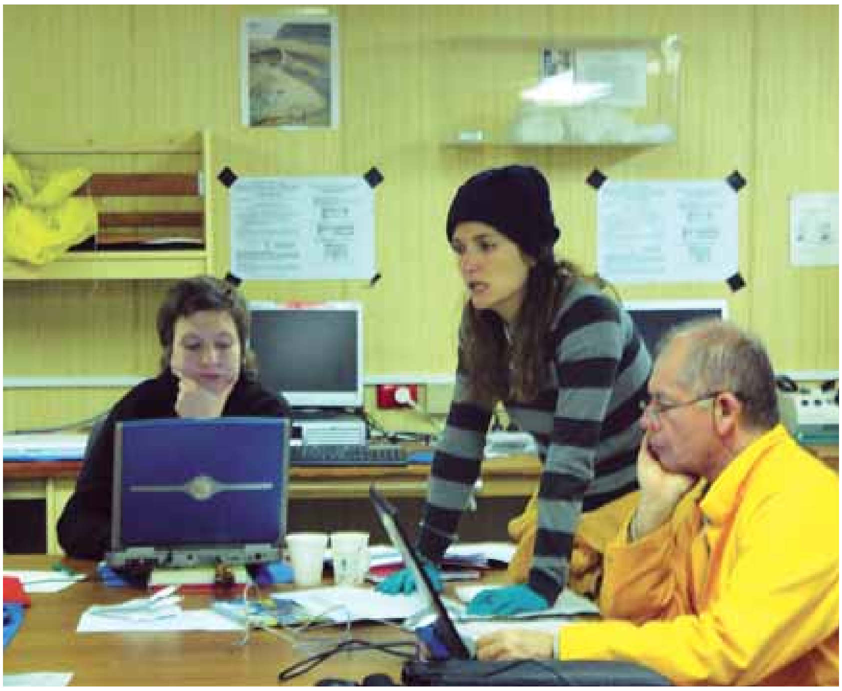
Is that where the CO_2 pump is at its busiest?

Yes, but you mustn't get the idea that the Antarctic Ocean is an especially fertile region. This is a myth. It is an HNLC system: high nutrient, low chlorophyll. A system with a high supply of nutrients but overall little chlorophyll. All the macro-elements that phytoplankton needs to grow are present: carbon, phosphorus and nitrogen. But proportionately we find far too little phytoplankton biomass, indicating that the nutrient supply is not utilised. The reason is well known: there is no iron, which is needed for a whole suit of cellular processes.

Does that mean fertilise with iron anyway?

Indeed not. It may actually be the case that the barren, desert-like areas are proportionately more efficient at exporting carbon than the nutrient-rich areas! At Kerguelen we noticed that a surplus of nutrients leads to sloppy feeding: lots of prey leads to lots of waste. Cells are half digested and you get a strong development of bacteria that profit from the opportunity.

Artificial fertilisation experiments induce a perturbation of the system. You change one cog in the gears. You throw a load of iron on the water but the system doesn't have the time to adjust. The phytoplankton reacts strongly to iron supply and will bloom, but the zooplankton and the bacteria follow at a different pace, with some delay, triggering a vast export of carbon to the deep sea. However, I am convinced that in case of long-term artificial fertilisation zooplankton and bacteria activities will again keep pace with phytoplankton activity, after which the efficiency of the carbon pump, which originally was high, will decrease again. So the efficiency of iron fertilisation is unlikely to remain constant in the long term because of this plasticity of the plankton community. Such variability should be factored into biogeochemical models. Finally, we need to be conscious of the fact that CO_2 does not stay stored forever in the deep sea. The system is bound to adjust.



VUB scientists interpret the first research results aboard the Aurora Australis: (from left to right) Anne-Julie Cavagna, Stephanie Jacquet and Frank Dehairs.

IceCube throws new light on neutrinos At the south Pole

This is a gigantic tool. The entire set of 86 cables and their 5 160 photomultipliers take up a volume of one cubic kilometre, from which it gains its name: IceCube.

Construction of a giant neutrino telescope has recently been completed at the South Pole (in January 2011). It took seven years to assemble some 5160 photodetectors in the Antarctic ice beside the American Amundsen-Scott Research Station, which together form this fantastic tool which is expected to detect the invisible. This is a tool which, like a number of other major international projects set up in polar regions, has also been given the IPY (International Polar Year) stamp.

This is an international project run by the University of Wisconsin at Madison in the United States, explains Daniel Bertrand of the Institut interuniversitaire des hautes énergies (ULB-VUB). The physicists at the Universities of Mons and Ghent, as well as those from the ULB and the VUB, have been taking part in this since the start. The connection with the International Polar Year has made it possible to accelerate its construction and to start recording data.

Here's another detail about the organisation of this project, which has a budget of USD 279 million and brings together 260 researchers from 36 different institutions: the scientific manager of this scientific adventure from the United States is none other than a physicist of Belgian origin, Professor Francis Halzen! A physics graduate from the VUB, his entire career was at Cern in Geneva until he joined the University of Madison.

The purpose of the IceCube project is to seal a set of photomultipliers in a cube of ice one kilometre square to detect the feeble glow that a cosmic neutrino may generate when it hits an atom. These photomultipliers are the size of a football. They are linked in series of sixty. These strings of detectors are arranged in the polar ice at a depth of between 1 450 and 2 450 metres. The entire set of 86 cables and their 5 160 photomultipliers take up a volume of one cubic kilometre, from which it gains its name: IceCube.

The last row of photomultipliers for the IceCube neutrino telescope was sunk into the ice of the South Pole in early 2011. The telescope goes down to a depth of 2 450 metres.

This is a gigantic tool , says Georges Kohnen, a physicist at the University of Mons, who took part in two summer campaigns while the telescope was being constructed. This is both a human adventure and a technological one. It was necessary to be creative to sink the strings of detectors into the ice. The job was done using hot water at 80 degrees. During the first year, a single string of detectors was sunk into the ice. The rate increased during subsequent seasons.

Neutrinos are basic particles which hardly interact with matter. They are created by nuclear reactions and arise, for example, within stars, in supernovas. Some of them even come from the Big Bang. Thousands of neutrinos pass through us every second without doing any harm. There are however significant interactions with matter. A reaction occurs from time to time. To study these, researchers have to try to uncover the signature of one or other of these interactions. For this reason they install their detectors in large quantities of matter, such as the ice in the Antarctic which, moreover, offers the advantage of being transparent and, at those depths, completely dark, which is essential when tracking neutrinos. When a neutrino interacts in this environment, it breaks down into a muon, a charged particle which can spread in matter and generate a feeble light, which is known as Cherenkov radiation, which continues to spread in the ice. This luminous trace betrays the passage of a neutrino, which tells researchers about the origin of the particle whose luminous trace ‘lights up’ certain detectors one after the other, making it possible to reconstruct the precise trajectory of the particle and therefore its origin.

The particles that interest the researchers involved in IceCube are therefore neutrinos of cosmic origin. To ensure that their data is not contaminated by other kinds of neutrinos, such as those that originate from the atmosphere, researchers look towards the centre of the Earth. This acts as a screen, because it halts most other particles. Only the traces that ‘mount’ into the telescope are therefore of interest to scientists, even if these are not all ‘cosmic’ neutrinos.

The new telescope has already shown what it is capable of doing. Its detectors have already captured several events. The researchers have also been able to determine the effect of the Moon on their flow of data. When the Moon passes in front of the telescope it also acts as a screen for the particles. We have therefore detected a decrease in the signals created by this additional screen in the signals captured by IceCube, explains Georges Kohnen.

IceCube is expected to operate for ten years at least.

The ULB’s glaciologists monitor the IceCube

The gigantic mass of ice into which the IceCube telescope has been sunk is extremely stable. At the same time, the glaciologists at the Université Libre de Bruxelles have profited from the construction of this tool to link inclinometers to certain chains of photodetectors sunk inside the bowl. The point of the exercise is to measure distortions in the ice over time, to analyse the forces acting on the ice, and to understand the flow speeds better.

Microbes from the cold

1 2

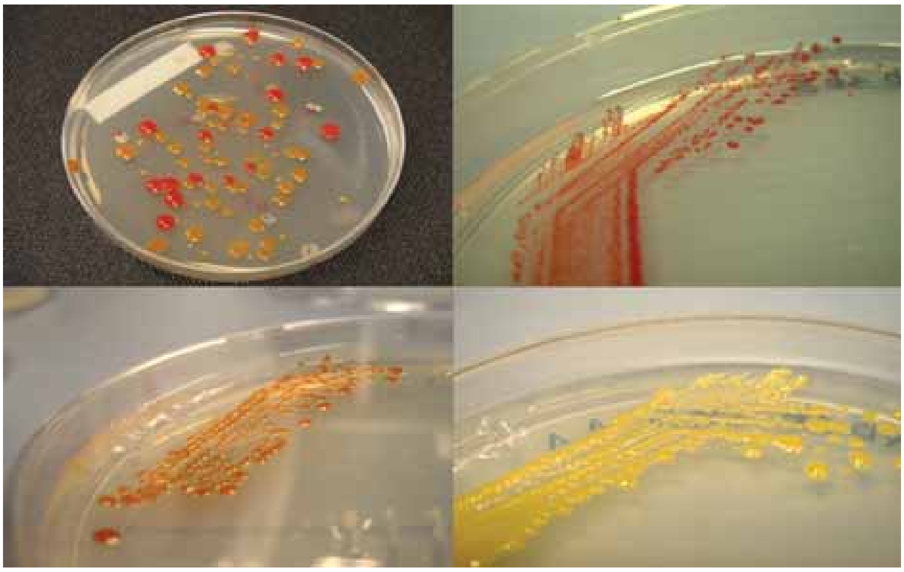
1 Scientists exploring the vast environment around the Belgian polar base: (from left to right) Karolien Peeters, Cyrille d'Haese (CNRS, Paris), Annick Wilmotte (ULg), René Robert (photographer/ mountain guide), Steve Roberts (BAS, Cambridge).
2 Karolien Peeters in search of undiscovered species.

Karolien Peeters wrote her doctoral thesis on microbes from Antarctica. She studied samples from areas including the environment around the Princess Elisabeth Base. The samples were taken in 2007 by Damien Ertz, a biologist from the National Botanical Gardens in Meise, who was commissioned by BELSPO to carry out an exploratory investigation at the site where the new Belgian Research Base was to be built. In 2009 Karolien got to go to Antarctica herself when the Princess Elisabeth Base became officially operational.

Karolien Peeters:
I had the honour of giving a presentation fot the guests at the official opening of the base! Only the day before we were running around with the vacuum cleaner trying to get everything ready. I found it a very useful experience to stand there and feel for myself just how tough living conditions are for these 'little creatures' I study. But I'm not exactly dying to go back again. It's absolutely freezing there and I'm not too good in the cold.

Karolien's promoter is professor Anne Willems, team leader at the Microbiology Laboratory at the Universiteit Gent. During the International Polar Year, her team was involved in a number of international research projects on the diversity of microbial life in the Antarctic (AMBIO and BELDIVA) and on the ecological implications of setting up the Belgian base (Antar-IMPACT). The Gent Microbiology Laboratory is also a contributor to the ANTABIF project (Antarctic Biodiversity Information Facility), a web portal giving access to a network of international databases on Antarctic biodiversity data. The Laboratory in Gent is home to the Belgian national collection of bacteria (BCCM/ LMG Bacteria Collection).

Anne Willems:
The International Polar Year and the construction of the Belgian base has been a major stimulus for us. We have always been interested in the Antarctic, but this mobilisation of people and resources by the Belgian government has paved the way for a lot of projects. The bounty of samples that Karolien and others have brought back from the Antarctic will keep us busy for years to come.



Bacteria from Antarctica cultivated in the laboratory in Gent.

Karolien Peeters:
When I arrived, the base was still being built. There was a lot of snow around so we were unable to see the marks that Damien Ertz had made in 2007. As soon as I was able I concentrated on taking samples from different biotopes: pebbles, lichens and algae, where bacteria thrive. I brought them all back to Belgium. You need a well-equipped laboratory to study microbes. The real work starts later, here in Ghent. That is what we are doing now. There was a field microscope at the base. Our colleague from Liége, Annick Wilmotte, had brought it along. It was handy for separating cyanobacteria, lichens and algae, but a light microscope is only of limited use for bacteria.

Anne Willems:
Bacteria are not easy to study. They are so small you can hardly make them out. Under the microscope they look round or straight or curved. But that doesn't tell you exactly what you have in your sample. Previous research, including the doctoral thesis of Stefanie Van Trappen in 2004, has revealed an enormous bacterial diversity in the samples from the Antarctic.

Karolien Peeters:
But the samples she had were mostly from the coast of Antarctica, the more easily accessible part. The samples from the Princess Elisabeth Base are of particular interest because they come from the interior, an area where it is much colder, with katabatic winds and more extreme conditions. And we have seen that the bacterial diversity is much greater than we expected! We keep finding a lot of new *taxa*, potential new families, new species.

Anne Willems:
To properly identify bacteria we have to isolate them and then cultivate them in the laboratory. And it seems that 80% of the isolates from the Princess Elisabeth Base could belong to new species! That is an enormous amount. I say could, because we have to study them in detail to be sure.

This is extremely important, given that only about 1 to 3% of the bacteria on Earth have been cultivated up to now and are thus well known. This is something on which scientists agree. This implies that we haven't yet identified 97% of the bacteria on the planet. Consider the things we can do with the 3% we already know: the useful enzymes they give us, antibiotics, colourings, medicines, water purification agents, bioremediation of polluted land, and so on. All with the three percent we have found to date. Imagine the potential locked up in the 97% we don't know!

Karolien Peeters:
There's plenty of work there without having to go to Antarctica you might think. But the bacteria that live in Antarctica have special qualities. They have adapted to the extreme conditions. That is why they are of great interest. In industrial applications we frequently see a need for high temperatures to get processes involving useful enzymes started. These are enzymes provided by bacteria from a temperate or hot climate. If they can be replaced by enzymes from Antarctic bacteria it might be possible to start the same production processes under colder temperatures. That would save a great deal of energy.

The arctic fox

The arctic fox (Latin name Vulpes lagopus) is a small fox that lives in the northern polar region and was bred for its pelt in the years between the World Wars. At home in a region where it gets extremely cold in winter, the arctic fox can survive temperatures down to -70 °C.

POLARCAT follows developments in pollution in the Arctic

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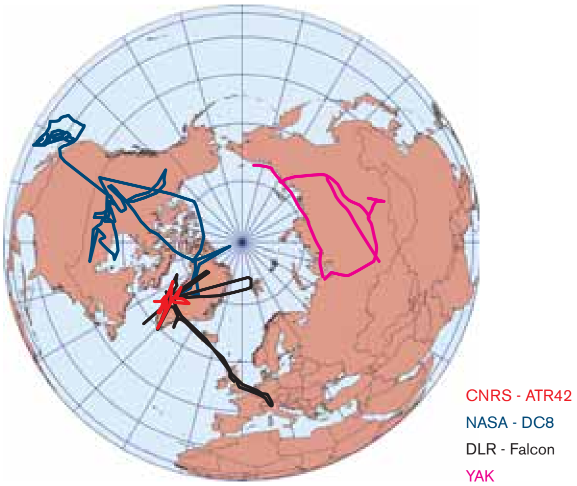
The Arctic, with its pack ice, its ice sheets which in particular cover Greenland and Svalbard, and its polar bears, is not the immaculate polar region people like to imagine! White is certainly the dominant colour.

POLARCAT summer 2008 aircraft campaigns



But this white is not synonymous with purity, notes Pierre Coheur from the Laboratory for Atmospheric Spectroscopy, Quantitative Chemistry and Photophysics at the Université Libre de Bruxelles. The Arctic is polluted by a whole series of particles deriving from human or natural activities which occur at lower latitudes. These particles, be they soot, aerosols or various chemical compounds, modify the albedo (reflective power) of ice. These atmospheric pollutants, which we see mainly in spring and in summer, generate a kind of fog, which is termed 'Arctic haze.' This haze, for example, reduces the intensity of the sun, but it mainly disturbs the chemistry of the atmosphere in this region of the world during those months.

Pierre Coheur and his colleagues on the POLARCAT programme used various tools during the International Polar Year to study this pollution from its origins at medium latitudes until it arrives in the Arctic. Coheur, as a scientist at the ULB, is particularly interested in how these pollutants are transported. He concentrates his work on detecting and following carbon monoxide in order to trace them.

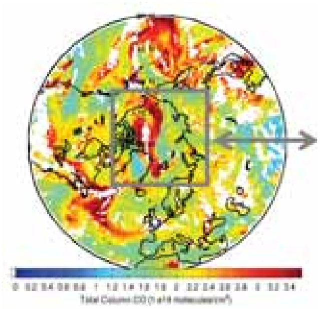
He does this by using data provided by the IASI instrument on the European Metop meteorological satellite, which is in a polar orbit. IASI stands for Infrared Atmospheric Sounding Interferometer. Designed by the CNES (the French National Centre for Space Research), it was placed on board the Metop satellite which is operated by Eumetsat. IASI is a perfect tool for detecting carbon monoxide and following its evolution from space, says Coheur. CO is a gas which lasts about 60 days, which allows us to follow CO plumes from the areas where they are emitted and see how they are transported over almost the entire hemisphere.

This space surveillance also makes it possible to plan the 'aircraft' campaigns in the POLARCAT programme. As soon as IASI detects a new plume, the information is transmitted to aircraft specially equipped to study the composition of these pollutants at various altitudes. The idea was also to understand developments in the chemical composition of these plumes, their distribution in relation to their altitude, and to verify the accuracy of satellite data, he says.

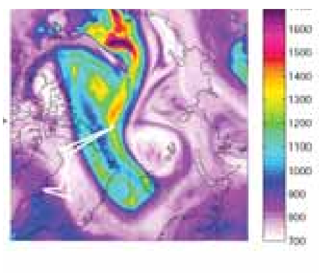
In this way we were able to compare the data coming from IASI with that collected on site by aircraft, both horizontally and vertically. This allowed us to demonstrate that satellite data were very reliable as regards total columns of carbon monoxide. On the other hand, data on vertical structures are definitely inferior. IASI is not capable of providing precise measurements of the vertical distribution of this pollutant. Our participation in this programme made it possible to observe phenomena whereby carbon monoxide is diluted or, on the contrary, to detect more concentrated plumes in certain locations. Our studies on transport mechanisms towards the Arctic have also shown that these processes may be quite rapid, making it possible for certain masses of polluted air to rise from medium latitudes towards the Arctic in only a few days.

Lastly, this research programme also provides data on forest fires. In this regard we have tried to explain a pyroconvection mechanism, that is the direct injection of gas at high altitude, which we did not know about before. This is a bit like volcanoes which generate significant thermic energy, concludes Pierre Coheur.

IASI CO satellite observation of CO columns (molecules cm-^{2}) 09-07-2008



Flexpart model simulation of CO transport CO columns (mg cm-^{2}) 09-07-2008



Man and Nature

Where does the pollution observed by the POLARCAT programme come from? This basically concerns pollution of man-made and urban origin (heating, transport) coming from Europe, Asia and the United States. Forest fires are another important source of pollutants. Scientists studied the plumes of several fires in Siberia during the International Polar Year.

The future belongs to the youth

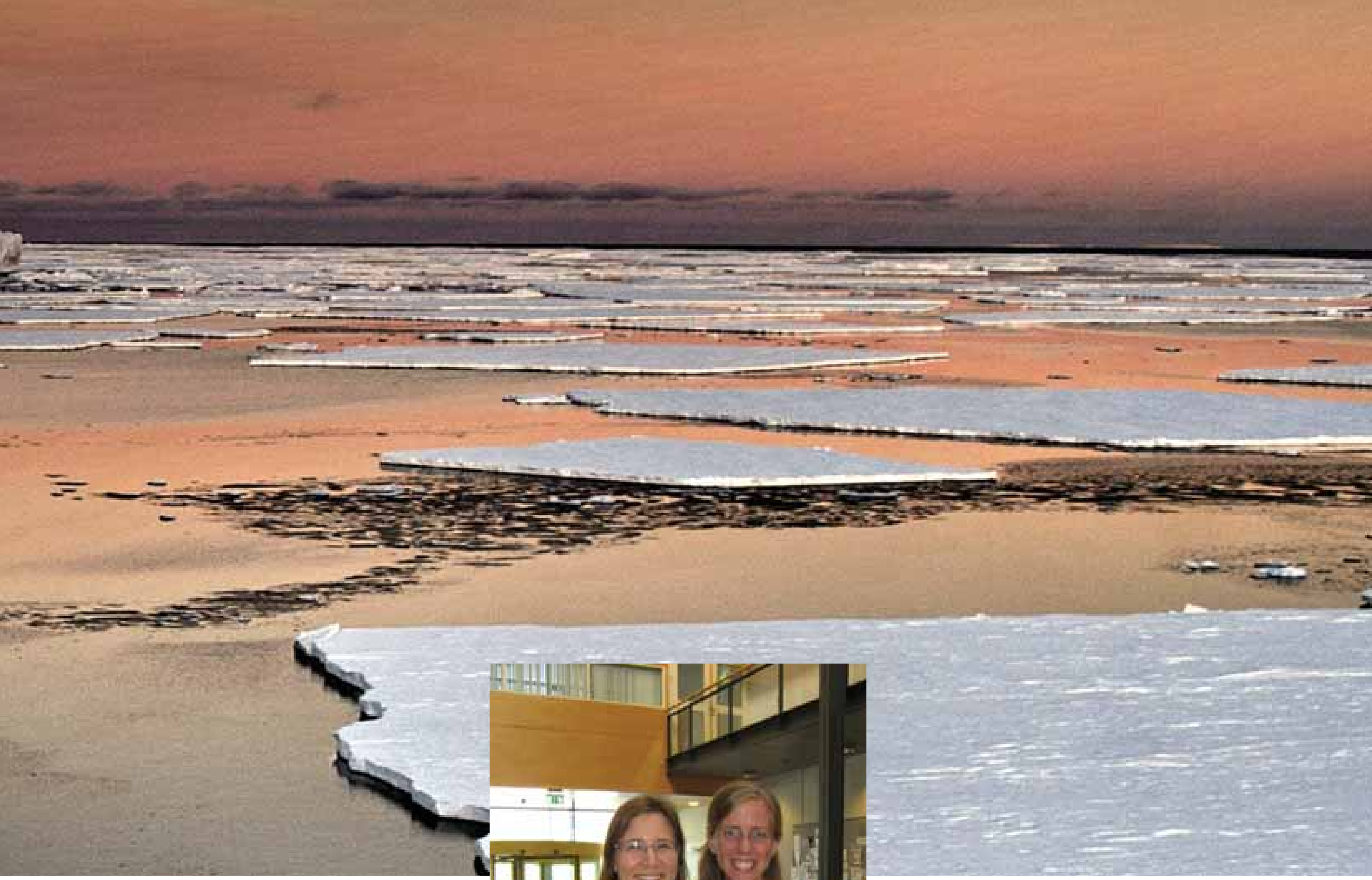
One important objective of the International Polar Year was to ensure the continuity of research and knowledge in the area of polar science by inspiring new generations of researchers and teachers. In 2005 the International Youth Steering Committee (YSC) was set up to warm youngsters to the idea of polar science and provide them with information. At the start of the International Polar Year the YSC joined forces with the Association of Early Career Scientists (APECS), an organisation with similar aims which was primarily geared towards polar researchers.

The Belgian YSC was chaired by Mieke Sterken, former doctoral student at the Universiteit Gent:

In October 2007 the Belgian YSC consisted of a heterogeneous network of young polar researchers including 9 doctoral students, 9 postdoctoral researchers, 1 bachelor student and 1 professional artist. This group represented 8 research institutes and universities. The research subjects covered by our members ranged from microbial and meiofauna ecology, through paleolimnology and glaciology to atmospheric and oceanic biochemistry. We also had our own website, set up by Bruno Danis, SCAR-MarBIN officer at the Belgian Biodiversity Platform.

We started with high ambitions. Because the whole of the YSC was based on volunteer work and most of its members were busy with full-time scientific research, we decided to focus on outreach and education, developing a network of researchers and keeping up with the International YSC.

We organised meetings, developed the website and created a flyer to hand out at events attended by young people. We gave interviews to youth clubs and on several radio



programmes. We also participated in several external events: for example, Denis Samyn spoke about his passion for his job as a researcher on Dream Day, an event for which more than 10 000 youth registered. In March 2008, my colleagues and me gave tours in the research labs during the UGent-aan-zee Open Day at Ghent University. I demonstrated the electron microscope and made an outreach poster about Antarctic sea level changes. Maarten Raes gave a talk about his Antarctic marine research with the help of photos and material from his expeditions.

And there was more: e.g., Elie Verleyen went around to schools giving talks to pupils in the third grade of primary school, and Anton Van de Putte presented a poster on the Belgian YSC at the 14th Benelux Zoology congress in Amsterdam in November 2007.

As chairman, it was my job to stay in touch with the International YSC and to report our activities to the chairmen of the other YSCs. We did this through telephone conferences with people from New Zealand, Canada, the United States, Portugal and many more countries. In September 2007 Caroline Souffreau attended on my behalf, as a representative of the Belgian YSC, a meeting of the International YSC in Sweden, where the foundations for the new APECS were laid. I also became a member of the APECS Outreach and Education Committee, where I put forward the idea to produce a Polar Resources Book: a book to contain educational material, ideas and classroom activities based on polar science. This book would be a permanent legacy for the younger generation in the International Polar Year 2007-2009. In the beginning I took charge of the project myself, but once I started getting really busy with my doctoral degree a number of people (e.g., Melianie Raymond, Rhian Salmon, Jenny Baeseman) and later Bettina Kaiser took over the editorial tasks on my behalf. The IPF also made 8 contributions. It was a great success. The book, entitled Polar Science and Global Climate, an International Resource for Education and Outreach, contains 237 pages of ideas, experiments, classroom tips and information on the Polar Regions and polar science. There is also a CD-ROM. I was there when it was officially presented at the International IPY congress in Oslo in July 2010. Something to be proud of, I think.

1 The ice barrier in Bryd Bay, Antarctica.
2 Mieke Sterken (right) and Nicola Munro (IPY programme officer) with the Polar Resources Book in Oslo.

contact details of the IPY participants

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Wim Vyverman	Universiteit Gent - UG	wim.vyverman@ugent.be	www.PAE.UGent.be
SCAR-MARBIN: A LEADING BELGIAN PROJECT FOR THE INTERNATIONAL POLAR YEAR - page 14			
Hendrik Segers	Biodiversity Platform	hendrik.segers@naturalsciences.be	www.scarmarbin.be www.antabif.be
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Lei Chou	Université Libre de Bruxelles - ULB	Lei.Chou@ulb.ac.be	www.ulb.ac.be/sciences/dste/ocean
Bruno Delille	Université de Liège - ULg	Bruno.Delille@ulg.ac.be	www.co2.ulg.ac.be/
Thierry Fichefet	Université Catholique de Louvain - UCL	thierry.fichefet@uclouvain.be	www.uclouvain.be/teclim
Hugues Goosse	Université Catholique de Louvain - UCL	hgs@astr.ucl.ac.be	www.uclouvain.be/teclim
Philippe Hyubrechts	Vrije Universiteit Brussel - VUB	phuybrec@vub.ac.be	www.vub.ac.be/DGGF
Christiane Lancelot	Université Libre de Bruxelles - ULB	lancelot@ulb.ac.be	www.ulb.ac.be/assoc/esa
Frank Pattyn	Université Libre de Bruxelles - ULB	fpattyn@ulb.ac.be	http://dev.ulb.ac.be/glaciol
Jean-Louis Tison	Université Libre de Bruxelles - ULB	jtison@ulb.ac.be	http://dev.ulb.ac.be/glaciol
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Mieke Eggermont	Universiteit Gent - UG	Mieke.Eggermont@UGent.be	www.aquaculture.ugent.be
Jean-Pierre Henriet	Universiteit Gent - UG	JeanPierre.Henriet@UGent.be	www.rcmg.ugent.be
THE BELGIAN ROYAL OBSERVATORY MANAGES THE GIANT-LISSA PROGRAMME - page 28			
Thierry Camelbeeck	Royal Observatory of Belgium - ROB	thierry.camelbeeck@oma.be	www.astro.oma.be
Michel Van Camp	Royal Observatory of Belgium - ROB	Michel.VanCamp@oma.be	www.astro.oma.be
THE ORIGINAL INHABITANTS OF THE ANTARCTIC - page 31			
Annick Wilmotte	Université de Liège - ULg	awilmotte@ulg.ac.be	www.cip.ulg.ac.be
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Jean Surdej	Université de Liège - ULg	jsurdej@ulg.ac.be	www.ago.ulg.ac.be
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Ann Vanreusel	Universiteit Gent - UG	Ann.vanreusel@UGent.be	www.marinebiology.ugent.be
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Hugo De Backer	Royal Meteorological Institute - RMI	Hugo.DeBacker@meteo.be	http://ozone.meteo.be
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Louis Beyens	Universiteit Antwerpen	louis.beyens@ua.ac.be	www.ua.ac.be
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Patrick Martin	Royal Belgian Institute of Natural Sciences - RBINS	Patrick.Martin@sciencesnaturelles.be	www.naturalsciences.be
Ann Vanreusel	Universiteit Gent - UG	Ann.vanreusel@UGent.be	www.marinebiology.ugent.be
Chantal de Ridder	Université Libre de Bruxelles - ULB	cridder@ulb.ac.be	www.ulb.ac.be/sciences/biomar

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Nicole van Lipzig	Katholieke Universiteit Leuven - KUL	Nicole.VanLipzig@ees.kuleuven.be	ees.kuleuven.be/geography
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Simon Chabrillat	Belgian Institute for Space Aeronomy - BISA	Simon.Chabrillat@bira-iasb.oma.be	http://bascoe.oma.be
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Sandra Vanhove	International Polar Foundation	sandra.vanhove@polarfoundation.org	www.educapoles.org
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Patrick Martin	Royal Belgian Institute of Natural Sciences - RBINS	Patrick.Martin@sciencesnaturelles.be	www.nauralsciences.be
Ann Vanreusel	Universiteit Gent - UG	Ann.vanreusel@UGent.be	www.marinebiology.ugent.be
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Frank Dehairs	Vrije Universiteit Brussel - VUB	fdehairs@vub.ac.be	www.vub.ac.be/ANCH
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Daniel Bertrand	Institut interuniversitaire des hautes énergies (ULB-VUB)	Daniel.Bertrand@ulb.ac.be	http://w3.iihe.ac.be
Georges Kohnen	Université de Mons - UMH	kohnen@umons.ac.be	http://icedb.umh.ac.be
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Anne Willems	Universiteit Gent - UG	anne.willems@ugent.be	http://lmg.ugent.be
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Pierre Coheur	Université Libre de Bruxelles - ULB	pfcoheur@ulb.ac.be	www.ulb.ac.be/cpm
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Mieke Sterken		mksterken@gmail.com	

This list is not exhaustive. Many other (often young) Belgian researchers and institutions have contributed to the realisation of the International Polar Year. For more information, don't hesitate to contact BELSPO: Maaike Vancauwenberghe (vcau@belspo.be).

In memory of Alexandre de Lichtervelde

defender of the Antarctic environment
colleague and friend
who has left us too soon.

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Coordination:
Maaike Vancauwenberghe (Belgian Science Policy).

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