PROCEEDINGS OF THE COMNAP SYMPOSIUM 2018

Facilitation of Internationally Collaborative Antarctic Science

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FACILITATION OF INTERNATIONALLY COLLABORATIVE
ANTARCTIC SCIENCE
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THE COUNCIL OF MANAGERS OF NATIONAL ANTARCTIC PROGRAMS

THE COUNCIL OF MANAGERS OF
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COMNAP Secretariat
Private Bag 4800
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Foreword

The COMNAP Symposium 2018 was held in Garmisch-Partenkirchen, Germany, on 14 June 2018, and was hosted by COMNAP Member the Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research. The theme of the Symposium was “Facilitation of Internationally Collaborative Antarctic Science”. By definition, “facilitation” is the act of helping others achieve their goals. In the case of national Antarctic programmes, facilitation entails sharing of specialised knowledge and skills in order to achieve long-term planning, dependable logistics chains, and implementation of the plans and policies to ensure scientists arrive where and when their research objectives demand. It also includes, among other things, technologies to appropriately collect, transit, and store data and samples. On top of all that, there is always a need for “Plan B”.

Science facilitation is a challenging task anywhere in the world. In the Antarctic, it is complicated by often daunting weather and physical conditions, by strict environmental management criteria, by risks to life and infrastructure that must be fully considered and minimised, by the sheer breadth of science disciplines we support, and by the vastness of the geographic areas across which polar scientists wish to work. It is also a relatively expensive endeavour. Because of all this and more, national Antarctic programmes recognised 30 years ago that collaboration, within COMNAP, provides the way to succeed.

The Symposium opened with a keynote showcasing the European Project for Ice Coring in Antarctica (EPICA) success story, a 10-nation collaborative effort to facilitate truly ground-breaking science. Professor Heinz Miller described what it took to retrieve and deliver two deep ice cores over a period of 11 years that have resulted, to date, in over 300 publications, which reveal details of our climate system extending back 800,000 years. The lessons learned during EPICA are being extended forward in order to recover ice that records climate even further back in time as part of the International Partnership in Ice Coring Sciences (IPICS).

There is no “one size fits all” to international collaboration. This is especially true if one considers the many different cultures we work across, the 19 different languages our national Antarctic programmes use in their day-to-day operations, and the varying environments and conditions across the vast Antarctic region. Many national Antarctic programmes have been working together, bilaterally or multi-laterally, for years. However, to push the forefront of science requires us to consider new arrangements, new technologies, and new ways to operate in previously unexplored areas of the Antarctic region. The Symposium therefore provided an excellent opportunity for national Antarctic programmes to share their experience with facilitation of internationally collaborative science as well as new plans for collaborations aiming to take Antarctic science to the next level.

The COMNAP Antarctic Roadmap Challenge (ARC) project teamed the science and science support communities to identify what is needed to get to that next level. One important theme that emerged was the need to facilitate projects that require the perspectives of many disciplines. Projects such as EPICA teach us that many of the science objectives identified in the SCAR Horizon Scan will require large, multi-national and multidisciplinary research teams, which in turn require long-term planning and diverse science support expertise. Within the Antarctic Treaty Consultative Meetings, the governance arm also continues to require good scientific research in order to inform policy-making. It remains critical that we take opportunities such as the COMNAP Symposiums to explore ways in which collective operations and logistics support our big international science initiatives but also contribute to national science successes and inform policy.

While some point to the small number of jointly administered Antarctic stations as evidence of a lack of international collaboration in the Antarctic Treaty region, COMNAP Annual

General Meetings and Symposiums show quite the opposite, and this year was no exception. Both the Annual General Meeting (AGM) and Symposium showcased collaborative sharing of fixed infrastructure, berths and lab space on ships, transport and data collection time on aircraft, and more, all of which not only strengthen science support but also enhance safety and environmental protection now and in the future. For example, all Antarctic infrastructure needs to be maintained and modernised, in order to meet changing demands from the scientific community and our environmental commitments. Several of the Symposium presentations and posters addressed modernisation in this context. Members examined traversing by conventional and not-so-conventional means as a way to extend our geographic support reach, and promoted new technologies toward more-efficient and safer science support.

This year's AGM and Symposium also provided an opportunity for those with existing research vessels, as well as many members ushering in new vessel capabilities, to expand collaborative support of the Southern Ocean Observing System (SOOS), the Year of Polar Prediction (YOPP), and the Southern Ocean Carbon and Climate Observations and Modeling project (SOCCOM). It is clear that the Southern Ocean continues to hold answers critical to the future of our planet, but, because of its vastness and challenging conditions, it remains largely under-observed. Members explored possibilities for a collective research vessel and autonomous systems "fleet" approach to addressing big science questions. The future for enhanced regional and full Southern Ocean science support is indeed a bright one.

I would be remiss not to highlight collaboration that takes place outside of the Antarctic by way of personnel exchange, sharing of data policies and best practice, hosting of international gatherings such as the Search and Rescue and Regional Working Group workshops, joint publications, joint technology development and deployment, and joint operations and logistics efforts.

The national Antarctic programmes have a long-term, proven track record of successfully facilitating not only their own countries' Antarctic science programmes but also internationally collaborative science. There is no sign that such activity is lessening. In fact, with the likes of IPICS and the Filchner Ice Shelf System (FISS) project, the planned Thwaites Glacier initiative, the envisioned East Antarctic Ice Sheet "ABC" Transect Initiative, the 10-year Korean Inland Traverse Programme, and the West Antarctic Peninsula latitudinal transect proposal, facilitation of internationally collaborative polar science is clearly on the rise.

As COMNAP looks over the horizon, we all look forward to continuing to work together to tackle both the well-known and the new challenges in order to facilitate and secure a scientifically productive, safe, and environmentally responsible Antarctic future.

Kelly K. Falkner
COMNAP Chair

Acknowledgements

This is the 18th COMNAP Symposium that has taken place; the first was held in Boulder, Colorado, USA in 1962. The Symposiums were first organised by the Working Group on Logistics of the Scientific Committee on Antarctic Research, then by the Standing Committee on Antarctic Logistics and Operations (SCALOP) within COMNAP, and they are now organised every two years by COMNAP.

The goal of the 18th COMNAP Symposium was to learn from historical, successful, internationally collaborative Antarctic science projects, and to showcase the breadth and depth of current internationally collaborative activities. The overarching theme of this year's Symposium, "Facilitation of Internationally Collaborative Antarctic Science", identified the reality that big science is not possible in the Antarctic without collaborative facilitation of that science. Some science projects take many years to plan, so that national Antarctic programmes are always working in advance of the science taking place in the Antarctic in order to identify science needs, resource implications, and personnel skills that will be required. National Antarctic programmes then put in place the science facilitation plan, and often a back-up plan or two, to ensure the project goals are met or exceeded. The Symposium keynote addresses provided context on past successes, and also some lessons learned, which can now be applied to future collaborations in science and science support.

The Symposium was a special event, which the Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research was very pleased to host in Garmisch-Partenkirchen, Germany.

As Convenor, I would like to thank the other Symposium Review Committee members, who were Félix Bartsch (Instituto Antártico Chileno), Robb Clifton (Australian Antarctic Division), and Chen Danhong (Chinese Arctic and Antarctic Administration), for their efforts in selecting the oral presentations from the submissions received and for chairing various Symposium sessions. Thanks also

to Eberhard Kohlberg and Christine Wesche, my colleagues at AWI, for assistance during the Symposium; to Michelle Rogan-Finnemore, COMNAP Executive Secretary, for her support in preparation for the Symposium and in publishing these proceedings; and to copy-editor, Janet Bray, for her efforts on the proceedings.

The number and quality of the applications for oral and poster presentations were very high and we are very grateful to everyone who submitted an abstract for consideration. The success of the Symposium is, no doubt, due to the work of the authors, co-authors, and presenters of the oral presentations and posters. Thanks go to each and every one who dedicated time and effort into the Symposium presentations and posters and who also provided the abstracts and papers that appear in this Symposium proceedings publication. We also had a very lively audience at the Symposium. Audience contributions, by way of comments and questions on the day, were very much appreciated, and so I would like to thank everyone who participated through their attendance. It was one of the largest COMNAP Symposiums ever held and we hope to grow the open event in future years.

It was a great pleasure to convene the COMNAP Symposium 2018, “Facilitation of Internationally Collaborative Antarctic Science”, and to see the publication of these proceedings as a record of the Symposium that will last into the future.

Uwe Nixdorf

Uwe Nixdorf
COMNAP Symposium Convenor
COMNAP Vice Chair

Contents

Poster Presentations

Oral Presentations

Tackling Expensive and Long-Term Science Projects in Antarctica: What we learned from EPICA

Heinz Miller
heinrich.miller@awi.de

Helmholtz Professor for Glaciology, Chair of the Scientific and Technical Council for *Polarstern II*, COMNAP Chair (2011–14), and Chair of the EPICA Scientific Steering Committee (2000–06)

Abstract
The European Project for Ice Coring in Antarctica (EPICA) represented a landmark science project in many respects. It was a multi-national project involving scientists and technicians from 10 European nations, not all of which had national Antarctic programmes, over a period of 11 years. It was successful in retrieving two deep ice cores, one at Concordia Station at Dome C, and the other at Kohnen Station in Dronning Maud Land. The two main goals were to get very old ice, and to get a high-resolution core covering the last glacial cycle for comparing the Antarctic record with the Greenland record. These main scientific goals were reached, and over 300 publications in high-profile journals are testimony to that. With hindsight, it is easy to say that this project was successful; however, getting there needed dedicated effort by many. EPICA showed that it is possible to tackle expensive and long-term science projects in Antarctica, in a concerted manner, between many different national programmes. It also proved that COMNAP is a major and able player in such undertakings. What we learned through EPICA can now be applied to current and future multi-national Antarctic research endeavours, including the search for, and eventual drilling of, the oldest ice, but also many other projects.

The ingredients of adventure: preparation

EPICA had many of the necessary ingredients to consider it an adventure. The project, which took place over 11 years, took preparation and hard work, it was exciting, and it provided rewards for those who took part and for the international community. All this adds up to adventure, by any definition. The preparations involved many organisations and individuals, perhaps beginning with the European Science Foundation (ESF). As early as 1986, through the then European Polar Science Network, planning began. There was a European *Polarstern* Study (EPS) in the Weddell Sea (1988–89), the Greenland Ice Core Project (GRIP, 1989–92), and the Polar North Atlantic Margins (PONAM) project (1998–93), which all laid the groundwork for EPICA.

In 1990, the ESF was formed, which along with the CEC-DG XII (Commission of the European Community - Directorate General XII) jointly established the European Committee on Ocean and Polar Science, an advisory panel tasked to: (a) develop a European long-term strategy on marine and polar research; and (b) foster major individual European projects in ocean and polar studies. This advisory group defined the research topics and then sponsored community workshops to allow the community to refine research terms of reference, to understand where sources of funding could be found, and to excite researchers who then became involved in the strategy.

For EPICA, the Ice Sheet–Climate Interaction Workshop (Aghia Pelaghia, Crete; September 1993) was of critical relevance and importance. The outcome of the workshop was a key paper defining the European glaciology programme, which declared the intent to drill two ice cores in the Antarctic. Eventually four "grand challenges"[1] were defined and these were submitted as draft proposals for funding consideration to ESF and CEC-DG XII. One of the four "grand challenges" was EPICA.

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[1] G. Hempel, ed., *The Ocean and the Poles: Grand Challenges for European Cooperation* (Jena: Gustav Fischer Verlag, 1996).

The ingredients of adventure: EPICA

The proposal included the intention to recover two Antarctic ice cores, one at Dome C and one in Dronning Maud Land (DML). From a scientific perspective it made good sense. The location at Dome C would mean recovery of very old ice with an undisturbed climate record, would provide a sample of the climate in warmer times, and would include data that represented signals from the India and Pacific Ocean regions. The location at DML would mean recovery of a record with higher temporal resolution than at the Dome C site, would involve ice from a previously unexplored region, and would include data from the Atlantic Ocean, thus providing optimal interhemispheric comparison. Also, politically, suggesting two ice core recoveries also made good sense and provided funders with options to consider.

Countries were then free to consider their interests in this “grand challenge”. In the end, 10 countries, including 12 institutions, were the partners in EPICA (Table 1).

	EPICA Partners
	Université libre de Bruxelles (Professor R. Souchez)
	University of Copenhagen (Dr J.P. Steffensen)
	Institut polaire français Paul-Emile Victor (Dr G. Jugie) & Laboratory of Glaciology (LGGE) Grenoble (Dr D. Raynaud, Dr J. Jouzel)
	Alfred-Wegener-Institut, Bremerhaven (Professor H. Miller)
	British Antarctic Survey, Cambridge (Dr E. Wolff)
	ENEA/Progetto Antartide, Rome (N. Cucinotta) & Università degli Studi di Milano-Bicocca (Professor V. Maggi)
	Institute for Marine and Atmospheric research Utrecht (IMAU) (Dr M. van den Broeke)
	Norwegian Polar Institute, Tromsø (Dr J.G. Winther)
	Stockholm University (Dr M. Hansson)
	University of Bern (Professor Th. Stocker)

Table 1: EPICA partner institutions and key personnel.

In the end, the project was funded to a level of approximately 25 per cent by the European Commission and the rest came from national contributions. Funding was an adventure in itself because it required co-ordination of different funding cycles.

National Antarctic programmes worked collaboratively to establish camps at Dome C and in DML.

Dome C

75° 06' S 123° 23" E 3,233 metres a.s.l. Average temperature = -55°C

Camp construction began at Dome C in the 1995/96 summer season. Drilling of the ice core began the next season, and in December 1998 the drill reached a depth of 780 metres then got stuck, and so activities were abandoned until the following year. December 1999 was the start of the second drilling season, and progressively from 1999 through January 2004 drilling continued until an ice core to a depth of 3,270 metres was recovered – meaning that at least 800,000 years of ice core data was recovered from the Dome C site.

Dronning Maud Land

75° 00' S 4° 07" E 2,890 metres a.s.l. Average temperature = -47°C

At the DML site, pre-site selection surveys took place over four summer seasons, beginning in 1996. In the 2000/01 season, Germany's Kohnen Station was built to provide the facilities for EPICA science and science support personnel, and drilling began. By January 2006, the drill depth was 2,782 metres and bedrock was reached, with an ice core retrieved that was at least 190,000 years old.

The drilling at both sites was supported by flights, land traverses, and various geophysical surveys, and required operations and logistics support to move people, equipment, and cargo in support of both site operations over the 11-year period of operations. All of this was done collaboratively, utilising the particular strengths and contributions from the various national Antarctic programmes involved (Figure 1).

Figure 1: Top – The team at Dome C; Bottom – The bedrock team at DML.

The ingredients of adventure: rewards

EPICA proved not only that large-scale, internationally collaborative science projects could be undertaken in the Antarctic, but also that they could be scientifically successful. Members of the EPICA team are responsible for over 300 published papers to date. The ice cores that were retrieved from Antarctica through EPICA continue to be the project's legacy, with ice held in storage repositories in Germany, and in Antarctica at Dome C.

Data from EPICA ice cores as published in *Nature*[2] has shown that atmospheric CO_2 is at its highest level in 800,000 years and that present PPMV of CO_2 levels are the highest in that same time period.

In addition to the legacy of ice cores and the numerous publications, EPICA's achievements are many. The EPICA science plan achieved its stated goals, and, in fact went beyond the goals. EPICA led to the development and application of new analytical methods still in use today. The project was completed within budget, contributed to public awareness of the importance of Antarctic science, and helped to develop technology, engineering, and science capacity in many countries. The significance of these achievements was recognised with the award of the Descartes Prize 2007 to EPICA in recognition of outstanding scientific and technological achievements resulting from European collaborative research.

EPICA is also now used as a model for fruitful collaboration in Antarctic science and science facilitation.

What next?

Through COMNAP, collaboration among national Antarctic programmes continues. The work of the 12-member EPICA consortium is continuing and others are joining in for the next big ice core project. The search for the world's oldest ice has begun, which, when found, could extend the record back to 1.5 million years. This would be interesting because, around 900,000 years ago, there was a clear change in the climate system. Since that time the glacial–interglacial cycle has been roughly 100,000 years. Before then, the cycle was 40,000 years. Hopefully, ice core data can help explain this, and only through international collaboration can we facilitate such important science.

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[2] See, for example, EPICA Community Members, *Nature*, 2006; and Luethi et al., *Nature*, May 2008.

The International Partnership in Ice Core Sciences (IPICS) Oldest Ice Challenge

Hubertus Fischer[a] and Tas van Ommen[b]
hubertus.fischer@climate.unibe.ch

[a]Professor and Deputy Head of the Climate and Environmental Physics Division, University of Bern, Switzerland, and Co-Chair of the IPICS Steering Committee
[b]Australian Antarctic Division (AAD) and Co-Chair of the IPICS Steering Committee

Abstract
The Middle Pleistocene Transition (between 1.2 and 0.9 million years ago) represents an enigmatic period in Earth's climate history, characterised by a shift in glacial–interglacial periodicity from 40,000 to about 100,000 years. The cause-and-effect relationship that led to this change is not fully understood yet, as important information on global changes in the climate system (such as the radiative forcing by atmospheric greenhouse gases) is still missing. Most of this information, including the phasing of these changes in the Earth system, can be derived only from a continuous ice core from Antarctica covering the last 1.5 million years. Ice of this age is likely to be found on selected sites on the East Antarctic Plateau, but as this ice will be in the bottom-most 200 metres, the chance of flow-disturbances is high and replicate drilling essential.

Accordingly, the IPICS community has identified the oldest ice challenge as one of their top priorities for the coming decade and several national and international oldest ice projects are currently in preparation.

Australian Planning for Contribution to the Oldest Ice Project

Rob Wooding and Anthony Hull
rob.wooding@aad.gov.au

Australian Antarctic Division (AAD)

Abstract

The Australian Antarctic Division (AAD) is well advanced with planning to contribute to the oldest ice project. These plans include: the establishment of a traverse capability; the establishment of a science ice core drilling capability; and undertaking operational activities towards retrieving a core, including participating in the internationally collaborative efforts. This paper outlines current capability development activities underway, along with broad operational plans and the potential requirements and opportunities for international collaboration.

Background

The Australian Antarctic Strategy and 20 Year Action Plan, launched by the Australian Prime Minister in April 2016, sets out Australia's national interest and our vision for Australia's future engagement in Antarctica. Through the Strategy, the Australian Government has committed to deliver an overland traverse capability with associated ice core drilling and mobile research station infrastructure, to enable Australia to take a lead role in major research projects, including the search for a one-million-year-old ice core (MYIC). In accordance with the 20 Year Action Plan, the Australian Antarctic Division (AAD) commenced in Year 1 (2016/17) preliminary scoping work for an overland traverse, mobile station, and ice coring capabilities. This year, Year 2 (2017/18), the commencement of building an overland traverse capability, with associated ice core drilling and mobile station infrastructure, is occurring, to enable planning with international partners to retrieve an MYIC. Year 5 (2020/21) will see the establishment of the traverse and mobile station, and commencement of scientific research to undertake the retrieval of an MYIC. The anticipated completion of the project is in Year 10 (2025/26). During this last year of the project we will work with international partners to interpret findings and publish results from the retrieved MYIC.

Timelines, science, and logistics

The AAD's planning for the project for the retrieval of the oldest ice has several distinct phases, being the design and procurement, establishment of the mobile station by traverse, and MYIC drilling and retrieval phases. The AAD's traverse, mobile station, and MYIC planning timelines are currently scheduled as:

2018/19 and 2019/20

- Capability design and procurement phase

2020/21

- Major cargo delivery to Casey research station by RSV *Nuyina* in November–December 2020
- Traverse # 1 (Proof of concept traverse; delivery of mobile station and MYIC infrastructure to drilling site commences)

2021/22

- Traverse # 2 (Delivery of mobile station and MYIC infrastructure to drilling site completed)
- MYIC pilot hole drilling

2022/23 through 2025/26

- Four MYIC drilling seasons

2026/27

- Contingency season (if required)

Proposed mobile station site

The proposed location for the mobile station is approximately 1,100 kilometres inland from Casey research station (Figure 1). It is close to Dome C and the joint French–Italian Concordia station, and also to the European drilling effort. While the site for the mobile station has been proposed, the exact site for the Australian MYIC drill effort is still under consideration.

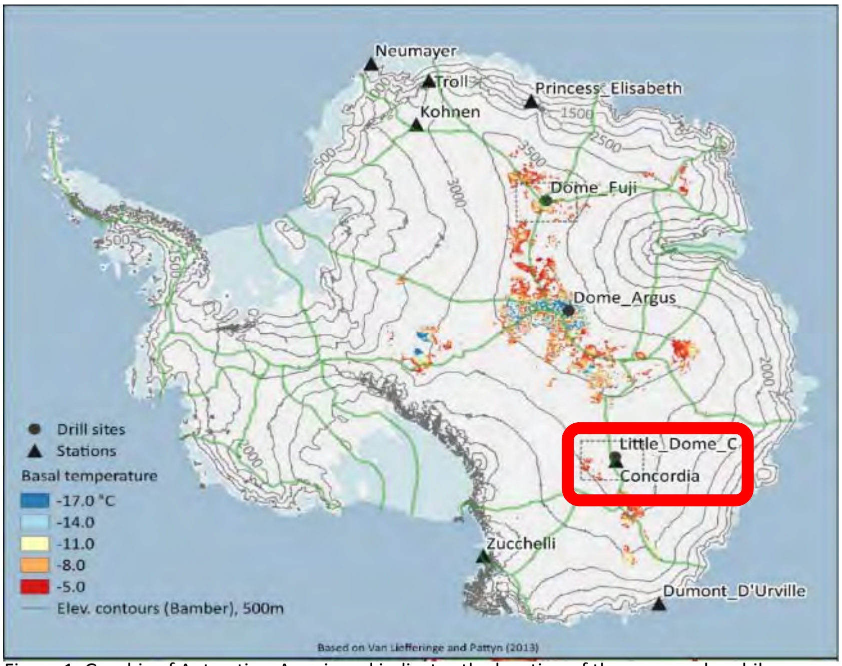

Figure 1: Graphic of Antarctica. Area in red indicates the location of the proposed mobile station site.

Proposed traverse route

The traverse will begin at Casey research station in East Antarctica. Such activities out of Casey research station are not new to the AAD and the organisation has a long record of numerous historical traverses in the late 1970s through to the mid-1980s. There is a proven historical route from Casey research station to the plateau from Law Dome, and a traverse route to Vostok Station. Various routes are being explored, including considering the opportunity for linking with the French–Italian traverse route from Cape Prud'homme to Dome Concordia and sharing a mid-point skiway. Once such a traverse route is proven, the route creates a ground logistics pathway from Wilkins to Casey to Dome C and potentially into Cap Prud'Homme.

Proposed new/increased capabilities

Traverse

The traverse will resupply the mobile station, towing approximately 320 tonnes, including people, fuel, food, samples, and temperature-sensitive ice cores recovered. The traverse will have to operate to ranges beyond 1,000 kilometres inland from Casey research station in order to reach the proposed MYIC drill site. The traverse team will be capable of preparing fixed-wing ski-landing areas, linking air capabilities between the traverse team and the Australian permanent research stations. It is proposed that the traverse and mobile station capabilities will endure for 20 years in order to meet future science demands.

Mobile station

The mobile station will act as an inland logistics hub, will accommodate between 12 and 16 expeditioners in the summer, will be designed to be winterised, and will operate each summer season. The mobile station will support the planned five-year MYIC drilling programme, including drilling operations, and ice core processing and storage. It will also have the capability and supporting infrastructure to establish and maintain a ski-landing area for fixed-wing aircraft.

Aviation

The Australian Antarctic Program (AAP) operates a network of landing sites in Antarctica each summer, with Wilkins Aerodrome being the intercontinental hub for East Antarctica. Wilkins Aerodrome, approximately 70 kilometres from Casey research station, services long-range, wheeled A319 Airbus and Royal Australian Air Force C-17A heavy lift cargo aircraft. Wilkins is open between October and March each summer, with some interruptions when temperatures are too high during the peak summer period. It supports approximately ten A319 and five C-17A flights each season for the AAP.

The AAP also operates sea-ice ski-landing areas at Davis and Mawson research stations, and plateau ski-landing areas at Casey, Davis, and Mawson research stations, for medium-range ski-equipped aircraft. These aircraft are currently a chartered Basler and a chartered Twin Otter, which provide an intracontinental link between Casey, Davis, and Mawson and other national Antarctic programmes' stations.

The AAD wishes to extend current logistics collaboration activities that are managed through a quid pro quo arrangement to provide new opportunities for collaboration on aviation access to and from Casey research station, and to and from the proposed mobile station site close to Dome C.

Shipping

The *Aurora Australis* (*AA*) is Australia's Antarctic flagship. It is currently the AAP's main platform for resupplying our research stations and conducting scientific research. The *AA* was commenced operational service in 1990. In 2020, the *AA* will be 30 years of age and a new shipping capability is being established by the AAD.

The RSV *Nuyina* will replace the *AA* and it is anticipated the ship will have a 30-year service life, and will be owned and flagged by the Commonwealth of Australia. The RSV *Nuyina* is a single multi-purpose icebreaking vessel that will support the AAP's primary mission to support scientific research and the annual station resupplies. The ship's secondary responsibilities will be to support other government agencies and provide an emergency response capability in the Southern Ocean. The RSV *Nuyina* will become the preferred means of supplying logistical flow to Antarctica, in conjunction with the AAP's aviation capabilities.

In comparison with the RSV *Aurora Australis*, the RSV *Nuyina* has approximately the same passenger capacity (117 pax), has increased cargo tonnage, increased fuel capacity, extended range (greater than 16,000 nautical miles) and greater icebreaking capability (1.65 metres at 3 knots).

Ice core drilling
The AAD is commencing drill development work for a deep drill capable of drilling to over 3,000 metres. Current plans are to build a drill based on designs from Denmark, the Ice Drilling Design and Operations from the University of Wisconsin (IDDO), and the European Project for Ice Coring in Antarctica (EPICA) drill. Collaboration with the Beyond EPICA – Oldest Ice partners and IDDO is in the process of being established. The AAD is seeking to develop its drill technology in co-operation with other international ice core drilling groups and consortiums.

Conclusion
There are a range of collaboration opportunities and the AAD is open to discussion with COMNAP Member programmes.

The East Antarctic Ice Sheet "ABC" Transect Initiative: Opportunities for international collaboration

Sun Bo and Tijun Zhang
sunbo@pric.org.cn

Polar Research Institute of China (PRIC)

Abstract
This paper presents a strategic vision for the Chinese Antarctic Research Expedition (CHINARE) investments in the East Antarctic ice sheet "ABC" transect initiative. The transect begins at the Chinese Zhongshan Station in East Antarctica and ends at Inexpressible Island in the Ross Sea Region. The traverse will go through Dome A, Ridge B, and Dome C, thus the "ABC" transect, connecting areas and data through airborne scientific survey routes and inland snow vehicle traverse routes. Such a project is beyond the capability of one nation alone to address, so CHINARE will encourage international co-operation on the ABC transect project.

Background
China's State Council has issued a set of guidelines to encourage more international "big science" projects. It is hoped that by coupling domestic and overseas capabilities and resources, China can contribute to major global scientific and technological challenges and play a significant role in international scientific innovation. The broad overarching theme is "Environment and Climate Change in the Three Polar Regions: Past, present and future".

"Big" Antarctic science
Contributing to our understanding of the East Antarctic Ice Sheet (EAIS) is a major undertaking. China's infrastructure in the Antarctic provides a good platform to launch scientific research in the area. It is proposed that the investigation of the region could be supported by the EAIS ABC transect initiative.

The multidisciplinary ABC transect would support the following strategic priorities in Antarctic ice sheet research:

- To understand the EAIS stability processes and the impacts on how fast and how much global sea level will rise, using remote sensing, geophysical surveys, ice modelling, and the records of past ice sheet change
- To support the Dome A deep ice core drilling project, and to connect deep-ice-core drilling sites by airborne ice-penetrating radar sounding to provide the inter-comparison of deep ice cores using internal isochronous layers
- To find the oldest ice core drilling site in Ridge B and understand the ice flow evolution in the region of Ridge B and the area upstream of the Vostok ice core site
- To seek the ideal blue ice site in the EAIS in order to drill and recover an ice sample possibly up to five million years old, which would provide insight into a period on the planet when carbon levels resembled that of today, to help to understand climate patterns and atmospheric carbon dioxide levels

Such a project is beyond the capability of one nation alone to address, so CHINARE encourages international co-operation on the ABC transect initiative.

CHINARE's research contributions

The acquisition and deployment of the aircraft known as "Snow Eagle 601" increases the capability of CHINARE to carry out airborne geophysical research in the Antarctic. This aircraft, with its custom modifications, is a ski-equipped DC3-T/BT-67 capable of carrying out air gravity and air magnetics measurements, collecting laser altimeter air photography, and undertaking ice thickness and internal ice measurements. Since 2015, the Snow Eagle has done a total of 68 flights, collecting geophysical data over 118,000 kilometres of East Antarctica and making the first-ever DC3 aircraft landing at China's Kunlun station.

Already, the data collected has revealed the nature of the subglacial topography in Princess Elizabeth Land, including the presence, location, and size of a canyon and subglacial lakes and their association with surface features. Preliminary results indicate a gravity inversion over the largest lake, which indicates that it holds at least 150 metres of water beneath the ice–water interface. Given that the Snow Eagle's round-trip range is 1,000 kilometres, it is a capable airborne research platform for operation across most of the EAIS.

In 2009, work began at Dome A on the Deep Ice Core Project in co-operation with Japan's National Institute of Polar Research (NIPR). Since that time, over six Antarctic summer seasons, a 801-metre ice core has been extracted. The Dome A Deep Ice Core Project has focussed on:

- new ice core dating methodologies;
- climate change mechanisms on varied time scales;
- new proxies for tracing past climate information;
- characterisation of the basal ice; and
- form and process of life beneath the ice sheet.

Data indicates that the Grove Mountains region of Antarctica is the ideal location to extract the oldest ice.

The ABC transect

Carrying out a traverse in the Antarctic requires infrastructure, assets, and capable people. In support of the ABC transect the inland traverse team will move from Zhongshan Station in the East Antarctic, through Taishan, to Kunlun station at Dome A, to Russia's Vostok station by way of Ridge B, to Dome C, ending at the proposed new Chinese station at Inexpressible Island in the Ross Sea Region (Figure 1). The team will be supported by a vessel at the beginning and end of the traverse, and also by aircraft and a range of land vehicles throughout the entire journey.

Along the way data will be collected in order to contribute to our understanding of ice sheet stability and to extract the oldest ice.

Figure 1: Graphic representation of the ABC transect.

Conclusion

The opportunity presented by IPICS is exciting. China's infrastructures, assets, and expertise are well-placed to contribute to the project. The ABC transect is an initiative to support China's contribution to the IPICS project and CHINARE looks forward to international co-operation on the ABC transect project.

Remotely Controlled Underwater Vehicle for Biological Science Research

Aleksei Gaidashov
alexis_33@inbox.ru

Belarusian Antarctic Programme

Introduction
Autonomous technologies were identified in the COMNAP Antarctic Roadmap Challenges (ARC) project as being critical to delivering science results across all disciplines. The Belarusian Antarctic Expedition is using remote controlled underwater technologies in support of biological research. This presentation is in the form of a seven-minute video, in English, that demonstrates the usefulness of autonomous technologies in support of international scientific research.

The challenges
Studies in marine waters and freshwater lakes of the Antarctic using diving equipment are accompanied by certain difficulties. For example, the impossibility of a diver staying under sub-zero water for a long time, as well as the working conditions of a rugged underwater and under-ice relief, limited under-ice space, and great depths. Diving during the southern polar night is especially problematic and raises concerns in regards to safety, yet winter data is critical for our understanding of year-round conditions and biology in the Antarctic.

Using remotely controlled technologies
One of the scientific tasks of the Belarusian Antarctic Expedition in the summer seasons 2016/17 and 2017/18 was the extension of the possibilities for carrying out field studies of marine and freshwater ecosystems by using an unpersonned underwater vehicle (UUV) referred to as “GNOM” alongside standard technologies usually used to carry out hydrobiological research, including diving equipment.

All in all, 12 research dives of both a diver and the UUV GNOM were carried out in the coastal marine zone and freshwater reservoirs of East Antarctica during the period from December 2016 to March 2018. A detailed underwater photo and video study was carried out; samples of representative marine flora and fauna were collected and genotyped, and their size and weight composition were determined; samples of benthal sediments and algal–bacterial tufts in freshwater reservoirs were also collected. The features of the formation and dynamics of the development of freshwater Antarctic lakes were also studied during the underwater diving, utilising three methods: the conventional method of diver-only, UUV GNOM-only, and UUV GNOM-plus-diver combination.

In the process of carrying out these field hydrobiological studies, Belarusian specialists have identified a number of advantages arising from the use of the UUV GNOM, either together with or separately from the work of the diver. These advantages are:

- the UUV GNOM is able to work to a depth of 150 metres and to move at speeds of up to 5.1 kilometres per hour with a submerged module weight of about 5 kilograms;
- the UUV GNOM is equipped with a manipulator with gripper for collection of biological samples, and a video camera with resolution high enough to recognise objects of 1–2 millimetres in size, for carrying out underwater photography and video recording;
- using the UUV GNOM requires a small number of personnel: only one to two people;
- the UUV GNOM is characterised by a lower weight as compared with alternative vehicles, due to the use of high-strength composite materials.

After testing, it was felt that the effectiveness of the UUV GNOM operation, both from shore and from ice, was considerable.

The Belarusian experts successfully tested the UUV GNOM with an array of various optional attachments, including a pH meter, a GoPro camera, a thermometer, a saltimeter, and a UV recorder. These were added in addition to the basic equipment of the vehicle during its operation from 2016 through 2018. These additions significantly expanded the range of possibilities for carrying out hydrobiological and hydrochemical studies in marine waters and freshwater reservoirs of the Antarctic.

Conclusions

The use of the UUV GNOM effectively allows us to supplement the traditional methods of hydrobiological and hydrochemical research, to replace divers in some cases, and to provide underwater research at low ambient temperatures, at any time of the year, in hard-to-reach places, in difficult underwater and under-ice relief, and in limited spaces. All of this sets apart the UUV GNOM from the more bulky and expensive devices of other systems, and it will be deployed in support of such research in future seasons.

WindSled: A clean, mobile platform for Antarctic research

Ramón Larramendi
ramon@tasermiut.com

Introduction

WindSled is the first wind-powered vehicle developed and adapted to travel in interior Antarctica for very long distances. It consists of a light convoy of sleds propelled by giant kites at altitude, capable of autonomously covering thousands of kilometres with no reliance on fossil fuels.

Background and development

WindSled was first tested in a Greenland crossing in 2000 and 2001. In 2005/06 a basic version was used in a crossing of Antarctica. In 2011/12 a second crossing of Antarctica was achieved with a more developed version, followed by several Greenland traverses in which improvement of capacity, payload, and scientific use was achieved. More than 20,000 kilometres have been successfully travelled with WindSled.

The concept

WindSled consists of a simple, efficient, light, and foldable sled, mixing traditional Inuit travel wisdom and techniques with innovative technology. Compared with other currently available options, it allows for simplification of logistics associated with land transects and traversing and reduces costs. It also provides an ecological solution with zero emissions, since it does not rely on fossil fuels.

Technical capabilities

WindSled is made up of three to four sled platforms, each measuring ten to fourteen metres long. These are foldable and therefore can be transported in a Twin Otter aircraft. Each WindSled is capable of transporting a team of six people on board, plus all things necessary for being autonomous for 50 days and a scientific payload of 300–400 kilograms (Figure 1). The maximum total weight of a full convoy, including sled and people on board, is 2,500 kilograms.

Figure 1: Photograph showing the WindSled configuration in use during the Greenland Ice River Expedition 2017. Photo: H. Moreno.

Applications in scientific research in interior Antarctica

WindSled is ideal for the remote high plateau of East Antarctica; all inland scientific stations can be linked by surface with WindSled. WindSled can provide sample and data collection: for example, transporting ice cores of a size and weight within the WindSled parameters. WindSled is versatile and can be easily customised and adapted for a specific project, therefore it is very practical.

Mathematical Modelling of Priorities and Costs of Vernadsky Station Infrastructure Modernisation

Oleksandr Kuzko, V. Lukiaschenko, and M. Leonov
uackuzko@ukr.net

National Antarctic Scientific Center (NASC), Ukraine

Introduction

The topical issue of the Vernadsky Station infrastructure system modernisation was investigated. The intention is to prevent accidents and failures of the infrastructure's constituent elements, to improve environmental conservation, and to carry out Ukraine's international obligations in the context of Antarctica.

The Antarctic Treaty Consultative Meeting (ATCM) XXXIII in 2010 adopted Resolution 3 (2010) *Revised Antarctic inspection Checklist "A"*, which could be used by inspection parties to verify, in particular, the technical conditions of Antarctic stations' infrastructures.

Vernadsky Station modernisation

In this work, the authors used both this Checklist "A" and the mathematical modelling of the hierarchies study[3] to obtain the quantitative characteristics of priorities and costs of Vernadsky Station infrastructure modernisation.

The quantitative characteristics obtained in the study provide the opportunities of:

[3] T. L. Saaty, "Decision making with the analytic hierarchy process," *Int. J. Services Sciences* l, no.1 (2008): 83–98.

- simulation of the infrastructure modernisation process according to the priorities, costs, and time to optimise the modernisation process in conditions both of limited funding and of limited time for the modernisation of Antarctic station infrastructure;
- preparation of the Feasibility Study, Request for Proposal and Working Project for the infrastructure modernisation;
- informing the general public about the Ukraine activities in Antarctica.

The developed method of mathematical modelling is proposed for the preparation and implementation of the system modernisation of Antarctic stations infrastructure of other Antarctic Treaty Parties to ensure the synchronisation, implementation, and carrying out of national and international scientific projects.

A Large, Grant-Funded, Science Project Established through an Infrastructure Loan Request

Mike Dinn[a] and Christine Wesche[b]
medi@bas.ac.uk

[a]British Antarctic Survey (BAS)
[b]Alfred Wegener Institute (AWI) Helmholtz Centre for Polar and Marine Research

Abstract
The UK Natural Environment Research Council and Germany's Alfred Wegener Institute (AWI) have just completed a three-season, broad-scale, systematic study of the Filchner–Ronne Ice Shelf and feeding ice streams within the Filchner Ice Shelf System project. The genesis of this collaboration was a straight logistics request by the British Antarctic Survey (BAS) to AWI for the loan of two PistenBully tractors. Negotiation over the loan of equipment very quickly led to a broader collaboration to establish a much larger multimillion-euro project, with significant logistics and scientific sharing between BAS and AWI, vastly enhancing the respective science plans.

Introduction
In 2011, COMNAP convened the Inland Traverse in Antarctica Workshop. During the workshop it became apparent that many national Antarctic programmes were building their capability and assets to support traverses in the Antarctic. For the British Antarctic Survey (BAS), 2011 was the end of the Halley 6 build, and it was also at that time that BAS made a request to the Alfred Wegener Institute (AWI) for the loan of two PistenBully tractors and a Lehmann sledge. BAS hoped to use this borrowed equipment during a science support traverse that was part of a UK Natural Environment Research Council (NERC) grant bid for the Filchner Ice Shelf System (FISS) programme. The loan was agreed following the COMNAP AGM 2013. But, in addition to the loan of the equipment,

both programmes quickly recognised that they had similar science plans but on two different, but closely related, ice shelves: BAS on the Filchner Ice Shelf, and AWI on the Ronne Ice Shelf. They also realised that a greater collaboration would boost both programmes' science outcomes.

Project outline

The Filchner–Ronne Ice Shelf (FRIS), is an ice shelf south of the Weddell Sea, divided into the Eastern (Filchner) and the larger Western (Ronne) sections by Berkner Island. The whole ice shelf and its five tributary ice streams span one fifth of Antarctica, cover some 430,000 square kilometres and comprise the largest (by volume) ice shelf in the world. The prime aim of the project is to determine how a large sector of Antarctica will respond in a warmer world. Projections will be made, for the middle of this century, of the amount of global sea-level rise from this sector should it melt. Understanding the FRIS required placing ice shelf instrumentation, drilling/coring, marine research cruises, and the use of autonomous underwater vehicles that went under the ice shelf. The ground traverse was supported by air operations that measured bathymetry beneath the ice shelf using geophysics. Overland geophysics was also used to determine flow and direction of ice stream feeds. A hot water drill was used to deploy instrumentation into the marine environment. Field measurements were carried out over three seasons.

Importance of discussion

Significantly, neither party was aware of each other's science plans in the region, strongly suggesting more-frequent discussion between national Antarctic programmes about science and logistics plans can lead to significant benefits. The equipment loan and modest equipment purchase allowed BAS to establish a second science support traverse, whilst concurrently running another NERC-funded study of the Pine Island glacier system. The cost of running two such projects concurrently would otherwise have been prohibitively expensive. Ultimately, in years 2 and 3 of the project both AWI-loaned equipment and the BAS tractors combined to run a four-tractor system. The combined system provided the necessary capacity for such a large project.

The proposed science could be expanded through increased and co-ordinated vessel movement and marine data collection efforts. In addition to ship efforts, there was aircraft support, logistics and scientific expertise, and specialist scientific equipment shared. To complement all of this effective use of resource, opportunistic logistic input of fuel and consumables for future project work has also been carried out.

Whole greater than the sum of its parts

Beyond the science delivered, the project proved to have important spin-offs for both partners. On both sides the collaborative way of working has built confidence in the other side. That is, both BAS and AWI recognise each other's strengths and can use that in future to work together. The larger combined pool of assets meant the scale of the science could be greater; that is, a bigger area could be covered with the sharing of logistics and operations support, such as fuel traverse and delivery to research field areas. The concept of a four-tractor science support traverse allowed for the possibility to apply for additional research funding, which, arguably, has brought an additional GBP 15 million research grant to BAS and more than GBP 10 million to BAS partners in the project.

For AWI the significance of the collaboration was that it opened the door for oceanographic and glaciological field studies on the Filcher Ice Shelf, since AWI was able to use the established BAS infrastructure. AWI scientists were able to conduct measurements in this region within this time frame that they otherwise would not have been able to do, and AWI was able to support the NERC-funded project with logistical needs and personnel on site. It changed AWI thinking in regards to field traverse methods.

Lessons learned

There are key lessons learned from this successful collaboration:

- Sometimes common goals are realised only through broader communication. Such communications within COMNAP need to include sharing ideas on operations and on science.
- Operational support can be as key to science outcomes as the science ideas themselves.
- Money need not change hands, as quid pro quo arrangements allow programmes to trade on their strengths and to learn skills from each other.
- Frank and open requests between national Antarctic programmes can sometimes lead to great outcomes and mutual benefit.

Conclusions

There are significant cost reductions to be had in equipment and operations sharing. There is also time-savings. For example, reduced ship time and aviation support time is often the result of good co-ordination across programmes and of good collaborations. There are often greater scientific benefits to be had from national Antarctic programme collaborations, and the sharing of expertise amongst programmes is enhanced during science support collaborations. Working together also gives broader international profile to all partners involved and therefore enhances outreach scope of the joint activity. It is clear that operations can lead the way to finding science synergies or can open doors to science opportunity.

Planning for the United Kingdom–United States Thwaites Glacier Initiative

Jessie Crain[a] and Mike Dinn[b]
jlcrain@nsf.gov

[a]US National Science Foundation, US Antarctic Program (NSF USAP)
[b]British Antarctic Survey (BAS)

Abstract
The UK Natural Environment Research Council and US National Science Foundation are supporting a five-year joint research effort in the Thwaites Glacier region of West Antarctica. The science objective is to substantially improve both decadal and longer-term projections of ice loss and sea-level rise originating from the Thwaites Glacier. The British Antarctic Survey and the National Science Foundation are in the pre-planning stages, in advance of field work scheduled to start during the 2018/19 summer season. The overall initiative will require substantial commitment of aircraft, traverse platforms, and research vessels, and will involve personnel and supply input from both the Peninsula and Ross Sea regions. Both organisations have mature planning models to support work in West Antarctica. In this presentation, we discuss the approaches we are using to integrate those models and to plan a complex collaboration, along with initial challenges encountered as we integrate multiple interdisciplinary research teams.

Introduction
Over the next four years, the United States and the United Kingdom will support the International Thwaites Glacier Collaboration in West Antarctica. The goal of the project is to evaluate the stability and history of the Thwaites Glacier and its possible contribution to sea-level rise. The funding process, logistics overview, and programme integration and interoperability are all presented here.

Background
The Thwaites Glacier programme was conceived as a fully collaborative joint effort between the US and the UK. A joint programme solicitation that went out in March 2017 required that each proposal have at least one US and one UK investigator within it. The US National Science Foundation (NSF) and the UK Natural Environment Research Council (NERC) reviewed the proposals received in a joint science panel with reviewers from both countries and with a single set of review criteria. Each country contributed an equal amount of science funding.

Eight projects – six with field work and two modelling projects – were selected. Logistics input and field science will begin in the 2018/19 season. The map (Figure 1) shows the primary field sites of each of the selected projects.

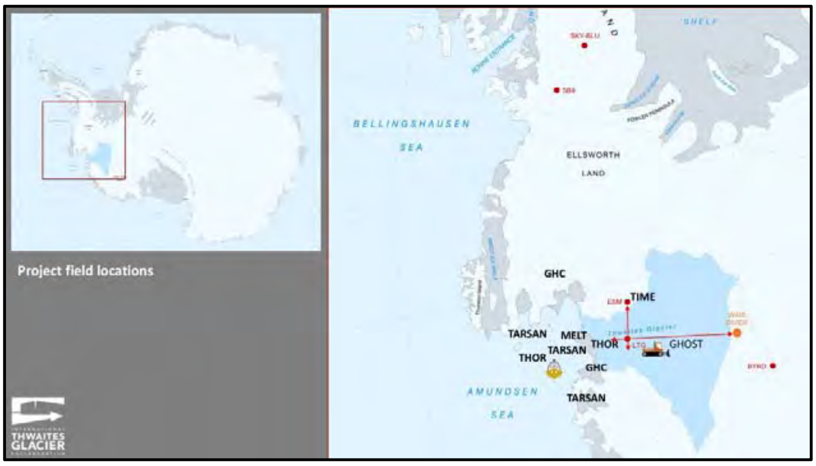

Figure 1: Graphic showing the primary field sites of each of the selected projects.

The working area is shown in the red box on the inset map, and is about equal distance from Rothera and McMurdo, in a part of West Antarctica that is difficult for both of the programmes to access. Over four years, the British Antarctic Survey (BAS) and the NSF aim to provide equal levels of field support, including research vessels, logistics and science traverses, and heavy and light aircraft.

Logistics overview

The first major logistics input of fuel and supplies will be the 2018/19 season by way of BAS vessel and traverse. The vessel will come into the continent at the Ronne Entrance in the upper part of the large map. The US will provide science support on the RVIB *Nathaniel B. Palmer* in the Amundsen Sea and logistics support to West Antarctic Ice Sheet (WAIS) Divide by LCH130 airlift from McMurdo Station.

In future seasons, the US will support logistics and science input through McMurdo to WAIS Divide. Both NSF and BAS will provide onward support to the field sites by small aircraft and traverse. The US will support another cruise on the RVIB *Nathaniel B. Palmer* in 2019/20.

The UK will send the RRS *Sir David Attenborough* during the final major science season, in 2020/21. In that same season, we will complete the field activities and begin to remove equipment. The collaboration also anticipates field and science co-operation with the national Antarctic programmes of the Republic of Korea, Germany, Sweden, and Finland. Over four field seasons, the full logistics commitment is significant (Figure 2).

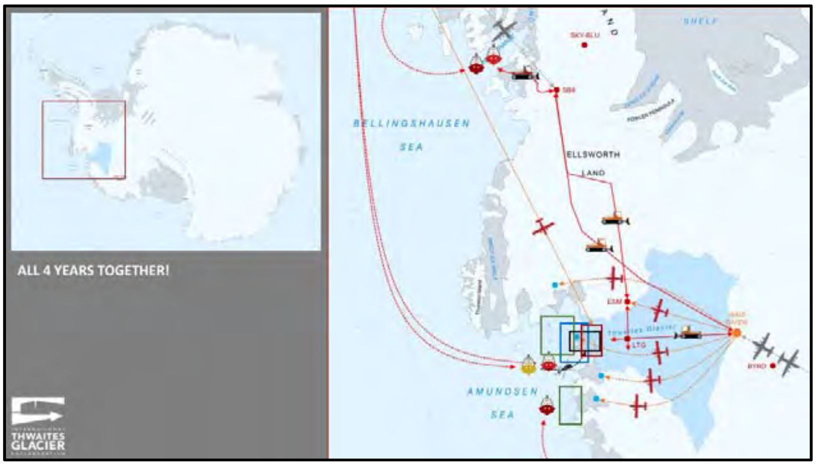

Figure 2: Graphic showing full logistics commitment over four seasons.

Programme integration and interoperability

Generally, BAS and United States Antarctic Program (USAP) operations are very similar, each with mature field support systems with many common elements. However, as planning began, we identified many areas where our operations and processes are not interoperable. In past collaborations, one programme took a clear logistics lead, and the lead programme drove the operating methods. In this case, as we aim to support the logistics equally, the integration is more critical and more difficult to resolve. A few of the areas we have worked on so far are common language, logistics chains, safety practices, field planning, and food.

"Common" language

Even though both programmes operate with English as our primary language, we have different terms and vocabulary. That difference even drove the name of our project, because we can't agree on how to spell program(me). We always have to be clear as to what our terms mean. For example, we have at least three different terms for the same type of fuel. These language differences are more critical when the collaborators do not primarily speak the same language.

Logistics chains
Our logistics chains are very different. BAS loads a ship in the UK, with some additional delivery directly to Punta Arenas, Chile. The BAS ship is our primary delivery for anything we want to input by traverse this year. The US delivers cargo by commercial ship and aircraft to New Zealand and Chile. Since we have been at this meeting, we have been working on a specific issue with purchase and delivery of seismic explosives. The NSF science programme has the money to buy the explosives, but purchasing and delivery to the ship in the UK are difficult for us. We need to find a way to complete this procurement in the UK, or find a way to transfer money to BAS or NERC to make the purchase, or buy and ship through our normal supply chain and then move the explosives to West Antarctica via LC-130 Hercules aircraft rather than on the more efficient traverse.

Safety practices
Both programmes have very high safety standards. But, even so, we have identified critical differences in field safety and operational procedures. We learned through a happenstance sighting of a drawing during a BAS visit to the US that we have opposite flagging conventions for flags or flag markers in the field. In the USAP, a black flag marks a danger zone and a red flag indicates a safe travel zone. For BAS, the opposite procedure is used, with red flags indicating danger and black flags indicating safe travel. Similarly, we are working through different protocols for roped snowmobile travel and rescue procedures, to understand where our systems are the same or just different enough to be dangerous.

Field planning
We also have different Twin Otter aircraft configurations, with major implications for field movement. The Kenn Borek aircraft that are chartered in the USAP have an extended door that allows for loading a wide-track snow machine. The BAS aircraft have a standard door, and the snowmobiles are modified to fit. When each country works on its own, this is not a problem. But as we

plan field movements for this collaboration, we must be sure that we match the snow machines with the right aircraft.

Food

A critical element of any field support is food. BAS provides their field teams with a food box in a few configurations while the USAP allows field teams to select from a variety of options while at McMurdo. While everyone will be fed, participants will likely have to get used to unfamiliar foods during their field seasons.

Conclusion

These issues are critical, and they are the tip of the iceberg for planning. A member of the NSF Polar Programs advisory committee asked if it is worth it, to work through all of the challenges to merge our systems like this. The answer is “Absolutely”. Neither of our programmes could accomplish anything this large on our own. The process is complicated, but we hope that the science results will be worth the effort.

A Multi-National, Multi-Partner Antarctic Research Fleet: A dream of the past or the way to the future?

Hyoung Chul Shin, Ji Soo Park, Key-Hong Park, and SangHoon Lee
hcshin@kopri.re.kr

Korea Polar Research Institute (KOPRI)

Abstract
The utility of a multi-programme research fleet in the Southern Ocean is as immense as it is difficult to arrange and operate. Such a fleet, even when loosely organised, is a powerful tool in addressing pending science and policy questions. We examined the past experiences as well as some of the planned exercises in order to determine possible fleet types and the range of objectives that could be achieved. The most common cases of fleet dispatch would be to dispatch many vessels at the same time over a large area to obtain a synoptic picture, often circumpolar. The other case would be to have a good number of ships sail on recommended tracks as opportunities arise, and compile data accordingly. A third approach would be to have a small number of ships visit the target areas that are often difficult to access. Our proposal for the future is to augment the fleet with newly emerging automated instrumentations that can manoeuvre freely or as programmed. The cases of BIOMASS, CCAMLR 2000, GLOBEC (as well as those of MEASO, and SOCCOM) provide useful references, indicating that the cost involved does not diminish the value of a research vessel fleet.

Background
The history of large-scale marine scientific efforts in the Southern Ocean dates back to the 1920s and is related to the harvest of Antarctic marine living resources. The Discovery Investigations of 1924–51 were a series of scientific cruises and shore-based investigations into the biology of whales in the Southern Ocean. The work was funded by the British Colonial Office and organised

by the Discovery Committee in London, which had been formed in 1918. This series of scientific investigations over many years contributed significantly to our knowledge of the whales and the krill that they fed on, and also contributed to our understanding of oceanography, including whale and krill habitats, and charting of the topography. This series of investigations resulted in 37 published volumes, with the final report being published in 1980. One of those 37 reports (Discovery Report 32, 33–464) was by Marr (1962) and was entitled *The natural history and geography of the Antarctic krill (Euphausia superba* Dana*)*.

Case study 1: Biological Investigations of Marine Antarctic Systems and Stocks (BIOMASS)

This programme, known as BIOMASS, was established in the late 1970s for the study of the Antarctic marine ecosystem and its living resources. Within BIOMASS, three major field experiments were carried out between 1981 and 1985, divided into two periods. The First International BIOMASS Experiment (FIBEX) took place in 1980–81 and the Second International BIOMASS Experiment (SIBEX) in 1983–85. Across the two periods, a total of 34 research cruises were carried out. The objective of BIOMASS was to obtain a deeper understanding of the structure and dynamic functioning of the Antarctic marine ecosystem, with a particular focus on krill.

Case study 2: The CCAMLR 2000 Survey

The CCAMLR (Commission for the Conservation of Antarctic Marine Living Resources) 2000 Survey was cited as the first large-scale, multi-national, multi-vessel survey in the Southern Ocean since 1979. The survey was conducted using strict method protocols and within a 32-day time frame so that it provided a truly synoptic view of the oceanography, zooplankton, krill, and higher predator biomass and distribution for the Scotia Sea and Antarctic Peninsula region. The survey design used simultaneous dispatch of multiple vessels over a large area and interleaved ship transects, and commissioned a small number of ships to visit target areas that were off the usual research tracks. Together the vessels provided comprehensive data in order to estimate krill biomass, which was collected in a single, global, and long-term database.

Case study 3: GLOBEC

The Southern Ocean GLOBEC multi-national programme, which ran from 1999 to 2009, was designed to understand physical and biological factors that contribute to enhanced growth, reproduction, recruitment, and survivorship of krill, and also to understand the wintering-over strategies and the role of sea ice and circulation in krill survival.

Can we repeat these successes?

Perhaps the time is right to consider the development of a multi-nation, multi-programme research fleet that could work together to deliver results the likes of those achieved by BIOMASS, CCAMLR 2000, and GLOBEC. There are areas of the Southern Ocean that have yet to be fully investigated. These areas are often near to coastal Antarctic regions that also have not been thoroughly researched. One such area is the Amundsen Sea near the West Antarctic Ice Sheet (WAIS), which has been described as experiencing ". . . the most profound contemporary changes to the ice sheet . . ." (Rignot et al., 2008; Pritchard et al., 2012). There are several new vessels under construction that will soon be available, and innovative technologies are now allowing for autonomous deployment of various marine sensors and data loggers. The Korea Polar Research Institute has a plan to work with other national Antarctic programmes to begin discussions on the Southern Ocean Environmental Changes and Robotic Expedition Technologies (SECRET) project in order to discover the secrets of the Southern Ocean.

Issues to address

Such large-scale, multi-national projects always have issues to address. First, it must be recognised that all programmes are different; for example, in funding cycles and in operational commitment. Systematic dialogue is essential and it should be backed by institutional will and policy commitment that could be formalised among the partners through a support letter, memorandum of understanding, or research collaboration agreement. It also must be understood that Antarctic operations work with long lead-in times. So any work envisioned for future years needs to be agreed to in advance so as to give enough time for operational planning. In the Arctic, the Arctic Research Icebreaker Consortium (ARICE) is a strategy for meeting the needs for marine research in the Arctic. This may provide an example for a way forward.

Conclusions

Significant scientific achievements can be made by the use of multi-vessel research efforts. This fleet of research vessels, coupled with innovative autonomous technologies, can provide a significant advantage and deliver opportunities for marine research similar to what we have had in the past but with greater possibilities. Co-ordinating dialogues are critical and warranted.

New Zealand's New Antarctic Science Platform: A collaborative approach

Fiona Shanhun, Rebecca McLeod, Neil Gilbert, and Peter Smith
f.shanhun@antarcticanz.govt.nz

Antarctica New Zealand

Abstract
New Zealand is currently developing an "Antarctic Science Platform", which is a dedicated fund to support Antarctic research. The fund represents a longer-term investment in New Zealand's Antarctic research programme, and it provides an opportunity to establish a more co-ordinated approach to addressing science priorities. The Platform specifically aims to facilitate enduring international collaborations, align research efforts with policy needs, foster innovation through multidisciplinary collaborations and technology development, incorporate indigenous (Māori) knowledge, and integrate planning for science and logistics needs. Research priorities focus on understanding Antarctica's impact on the global Earth system and how this will change in a warming world. This paper highlights the aims of the Platform, outlines the planned research programmes, and notes opportunities to develop science and logistics collaborations with other national Antarctic programmes.

The New Zealand Antarctic Science Platform
Antarctica and the Southern Ocean are fundamentally important to the global climate system. Understanding the effect of changing environmental conditions in, on, and around Antarctica is critical for projecting and adapting to Antarctica's influence on New Zealand and the rest of the world.

In 2017, the New Zealand Government announced a new strategic science investment fund for Antarctic science. The investment is NZD 49 million over seven years, and Antarctica New Zealand, the government entity charged with delivering New Zealand's Antarctic research programme, has been contracted to host and implement the Antarctic Science Platform. Through the Platform, New Zealand researchers will "conduct excellent science to understand Antarctica's impact on the global Earth system, and how this might change in a +2°C (Paris agreement) world".

To meet its purpose, the Platform will address four science priorities, underpinned by three cross-cutting themes (Table 1).

Science priorities	
1	Understanding the stability of the West Antarctic Ice Sheet
2	Understanding the impacts of change in the Antarctic atmosphere and Southern Ocean
3	Understanding threats to ecosystem dynamics in the Ross Sea
4	Understanding change in terrestrial and nearshore Antarctic environments, and the connections between them
Cross-cutting themes	
1	Building innovation and interdisciplinary capability
2	Developing technology
3	Supporting and developing long-term data sets

Table 1: Antarctic Science Platform priorities and cross-cutting themes.

Two core research programmes

Following discussions with researchers and stakeholders, two core research programmes were developed. Programme One will focus on "The Antarctic ice–ocean–atmosphere system in a warming world". The overarching aim of this programme is to address how the Antarctic–Southern Ocean environment will change as the planet moves towards a +2°C world, and to project regional and global consequences of its warming. To achieve this, the programme will focus on developing the data sets and process understanding required to detect and anticipate the implications of warming, and to identify important thresholds and associated environmental change in Antarctica.

Programme Two will investigate “Ross Sea Region ecosystem dynamics in a warming world”. The focus of this programme is to enhance our understanding of ecosystem structure, function, variability, and vulnerability in the Ross Sea Region. Work conducted as part of this programme will help to improve detection of natural and anthropogenic change in these ecosystems, and data will inform projections of magnitudes, rates, and scales of environmental change and its ecological consequences.

Both programmes aim to link physical and biological systems, and will utilise a multidisciplinary approach in order to enhance innovation. Technology will support the collection of data in remote locations and at times outside of the traditional summer field season, providing data sets that are more comprehensive and more representative . Engagement with stakeholders and end-users from project initiation to delivery will better align research effort with policy needs. Ultimately, both programmes will facilitate detection, attribution, and anticipation of change in order to support evidence-based decision-making and management and to influence policy.

Our ambition

The Platform will build on New Zealand’s Antarctic research strengths. The intent of the Platform will be fully realised when New Zealand researchers are leading campaigns that are addressing the most pressing research questions, connected nationally and internationally, effective in supporting policy initiatives, future-proofed in terms of capacity building, and responsive to changing research priorities and opportunities.

The Platform also provides an opportunity to develop enduring science and logistics collaborations with other national Antarctic programmes. The longer-term certainty of funding afforded by the Platform will assist Antarctica New Zealand to integrate science ambition with planning for Antarctic logistics support. The long-term, programmatic view of field requirements (both in Antarctica and in the Southern Ocean) will enable early discussions regarding assets required to support complex field campaigns, while also highlighting opportunities for scientific collaboration.

Importance of International Scientific Collaborations for the Bulgarian Antarctic Programme

Dragomir Mateev, Christo Pimpirev, and Yordan Yordanov
polar@gea.uni-sofia.bg

Bulgarian Antarctic Institute (BAI)

Introduction

During the 30-year history of the Bulgarian Antarctic Expeditions, international collaboration in science and logistics has played a very important role. Statistics show that during those years, in addition to Bulgarian scientists, 64 scientists from 15 different nations have worked at the Bulgarian Antarctic Base (BAB) "St. Kliment Ohridski".

Projects focussed on the main science branches of geosciences, life sciences, physical sciences, and human medicine have been carried out at the BAB, as well as many interdisciplinary projects.

The infrastructure of the BAB provides a very good opportunity for work in different science fields for groups of a limited number of scientists. The BAB is organised in such a way that the logistics team is always able to support and assist researchers in their projects.

As a small programme, we try to work on many joint international projects, but we have also encouraged scientists with their own projects to join our expeditions when we do not have the ability to fill the capacity of the base.

The Bulgarian Antarctic Institute (BAI), through the years, has been a supporter of countries just beginning their research in Antarctica. We have been the host to the first scientists from Mongolia, Turkey, and Macedonia when they began their initial work in Antarctica. Very close collaborations, of more than a quarter century with our Spanish neighbours and more than ten years with the Portuguese Polar programme, contribute not only to important scientific results but also to the development of the infrastructure of the BAB.

However, none of this scientific collaboration would exist if it wasn't for the logistic support and co-operation of other Antarctic nations, such as Spain, Brazil, Argentina, Chile, and Uruguay.

International scientific collaboration provides an opportunity for creation and expansion of regional partnerships. The good practice of that is represented by the Bulgarian and Turkey partnership, which grew beyond the work at the BAB, with several joint meetings and events related to Antarctica.

Scientific collaboration

Scientific collaboration plays a key role in the process of Antarctic research. So much so that it is even stated as a provision in the Antarctic Treaty 1959. Articles II and III of the Antarctic Treaty focus on international co-operation in research, and state that Parties agree that, to the greatest extent feasible and practicable, they will exchange information regarding plans for scientific programmes, they will exchange personnel between expeditions and stations, and they will freely exchange scientific observations and results.

From the very beginning of the 30-year-long history of the Bulgarian Antarctic Expeditions, international collaboration in science and logistics, in the spirit of the Antarctic Treaty, has played a very important role.

Programme background

The Bulgarian Antarctic programme was born from international collaboration. In 1988, two Bulgarian geologists, Professor Christo Pimpirev and Professor Borislav Kamenov, spent four months on Alexander Island, working with the British Antarctic Survey. At the same time four more scientists and support workers placed the first Bulgarian buildings on Livingston Island with the logistics support from the Soviet Antarctic programme. Statistics show that since that first expedition more than 250 scientists have participated in and carried out projects at the BAB “St. Kliment Ohridski”. Of the total, 64 were from one of 15 different nations. Also, during the past 30 years, nine Bulgarian scientists have taken part in international collaboration projects at four different locations in Antarctica. These scientists worked on many different projects focussed on all the main science branches, including the geosicences, life and physical sciences, and human medicine, and also in multidisciplinary teams.

The BAB St. Kliment Ohridski
The infrastructure of the BAB provides a very good opportunity for groups in different science fields for a limited number of scientists at any one time. The BAB is organised in such a way that the logistics team is always able to support and assist researchers in their projects. As a relatively small programme, we try to work on many joint international projects, but we have also encouraged Bulgarian and international scientists with their own projects to join our expeditions. Every season, we endeavour to fill the station to its capacity and use the facilities to the best of their capability and capacity.

Long-term and current collaborations
We continue to work closely with our Spanish “neighbours” in Antarctica, just as we have done for the past 25 years. The collaborations are often logistics sharing, but we also support each other in the field, share data, and work on joint science projects. There is also a long history of co-operation with the Portuguese Polar programme. In 2008, we started a joint project with Portugal and Spain on permafrost. Since then, the BAB has hosted scientists from Portugal working on projects in many different spheres. This type of long-term collaboration is extremely important. It contributes to important scientific research and results.

The collaboration has also contributed largely to the development of the BAB infrastructure. Great examples of such developments are the installation of a meteorology station and the purchase of a Zodiac boat, needed for a joint project in the past and now serving the needs of all current projects.

Since their initial visits, scientists from Mongolia and Turkey have continued to work at the BAB. This supports the career development of early career researchers in those countries. Outside of Antarctica itself, international scientific collaboration provides an opportunity for creation and expansion of international partnerships developed through scientific seminars, joint meetings, presentations, and events related to Antarctica.

Bulgarian scientists can also capitalise on opportunities to work at other stations and facilities. For example, Bulgarian scientists have worked at the Byers Peninsula Spanish facilities and at Poland's Arctowski station. All of these scientific collaborations would not exist if it was not for the logistic support and co-operation of other Antarctic nations, such as Argentina, Brazil, Chile, Uruguay, and others.

The future

The importance of international co-operation cannot be over-emphasised. Such collaboration provided opportunities that would not be within the means of one programme alone. Collaboration has been an extremely important part of the past of the Bulgarian Antarctic programme and has helped to improve and develop the BAB. Collaboration in science will continue to be a focus for our future development.

Chilean Antarctic Programme: Horizons for co-operation

Marcelo Leppe
mleppe@inach.cl

Instituto Antártico Chileno (INACH)

Introduction

The recent Chilean Scientific Antarctic Expedition (ECA54) made by the Chilean Antarctic Programme was carried out with the support of a special vessel called *Karpuj* in order to expand the usual area of investigation. It allowed for, and facilitated sampling of, marine biology, oceanographic chemistry, and geology, and other data collection. In addition to *Karpuj*, the Instituto Antártico Chileno (INACH) Escudero station, and the Chilean Navy vessels and Air Force aircraft all contribute to our commitment to support internationally collaborative activities in the Antarctic Treaty region. Together, through international collaboration of others who regularly work in the Antarctic Peninsula region, there is an opportunity to understand conditions along a latitudinal gradient or climate transect.

Ingredients of the transect

Spanning the north–south length of Chile, adding to that the width of the Drake Passage and then adding again the length from the north of the Antarctic Peninsula as far south as Union Glacier, covers a transect of 4,565 kilometres (2,837 miles). Along this area (Figure 1) is a range of scientific facilities and data collection points on land, which can be coupled with vessel capability and autonomous technologies to collect data from the marine, terrestrial, and atmospheric environments that would cover a significant latitudinal gradient from approximately 41^{o} S (in Chile) to 79^{o} S (in Antarctica, in the area of Union Glacier).

For example in the 2017/18 season, the Chilean vessel *Karpuj* sailed 2,000 miles across the Antarctic region, and its oceanographic equipment allowed the deployment of the CTD-O up to 1,080 metres of depth, a significant depth. Reaching such great depths was only possible due to the special capabilities of the vessel, which has an A-frame, oceanographic winch and a CTD on board. *Karpuj* measures 25 x 5.24 x 2.2 metres; this means it can get into places where other, larger, ships cannot.

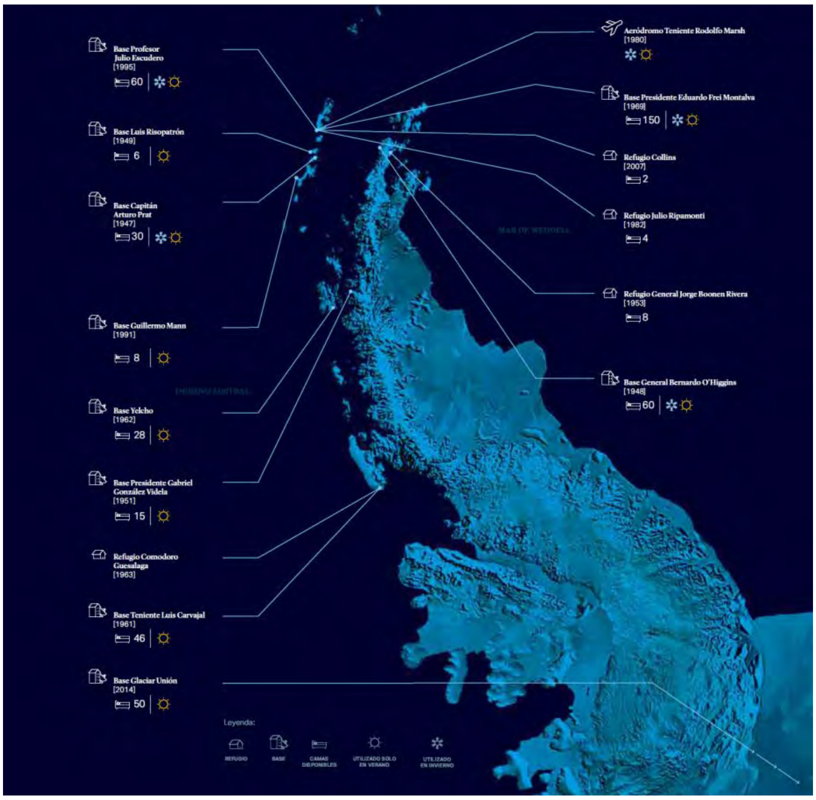

Figure 1: Chilean facilities located in the Antarctic Peninsula region.

International collaboration

While the ship *Karpuj* is proving to be a valuable asset, collaboration with other programmes remains the key to success. For example, geological sampling was completed by the Polar Research Institute of China in the King George Island area, and work with the Korea Polar Research Institute was undertaken on King George Island, on Deception Island, and further south near the Chilean Base Yelcho. There was also research undertaken in collaboration with the German and Poland national Antarctic programmes. The planning for the upcoming season is already well-advanced. We welcome continuing discussion from other national Antarctic programmes on how we can work together to support science in the Antarctic Peninsula region.

The Success of International Collaboration for Supporting Antarctic Science and Logistics: The operation of the Chinese first fixed-wing aircraft, Snow Eagle 601

Tijun Zhang,[a] Robb Clifton,[b] and Paul Sheppard[c]
zhangtijun@pric.org.cn

[a]Polar Research Institute of China (PRIC)
[b]Australian Antarctic Division (AAD)
[c]US National Science Foundation, US Antarctic Program (NSF USAP)

Abstract
The operation of the Chinese first fixed-wing aircraft could not be considered as a success without international collaboration both in logistics and in science. Many stakeholders have made substantial contributions to the development of the aircraft, including relevant national operators, the scientists, and the commercial operator. This presentation draws on knowledge and experience gained from the first three seasons of operation of Snow Eagle 601 in Antarctica and emphasises important learnings that will inform and advance future collaboration.

Snow Eagle 601 first CHINARE fixed-wing aircraft
The Snow Eagle 601 is a DC-3 modified to BT-67 aircraft that has science equipment on board. It is owned by the Polar Research Institute of China (PRIC), was modified by Basler, and is operated by Kenn Borek Air Ltd.

There are many challenges related to the operation of aircraft in the Antarctic. Programmes with air operations understand the high level of resource that maintaining such an asset requires. The first challenge is deploying the aircraft to the continent, which involves a lot of co-ordination and planning at home, and also hard work in preparation in the field. China does not operate a runway in Antarctica, nor does it operate directly to the Antarctic from its own gateway city or facility. So just deploying the Chinese aircraft presents a demand that requires a great deal of international collaboration among several national operators. The Snow Eagle uses the British Antarctic Survey Rothera station as its Antarctic entry point each season, crossing through Union Glacier and the US Amundsen–Scott South Pole Station on its way to Zhongshan Station. For departure, the Australian Casey station and the US McMurdo Station are also part of the usual routing. Refuelling is a critical part of aircraft operations, and, for this, the Russian Progress station is also used as a stopover point.

Science contributions

Science is the fundamental goal for CHINARE’s Antarctic aviation activities. Providing support for airborne surveys is not easy. Station support, ground support for flights, and co-ordination between pilots and scientists are all needed. From 2015 through 2018, the Snow Eagle has done aerial surveys across East Antarctica, in particular carrying out geophysical surveys as part of ICECAP and the Princess Elizabeth Land projects. In total, 68 flights, covering 118,000 kilometres, were completed.

In addition to science contributions, by using the Australian airlink to Zhongshan Station, deployment of people to the Antarctic can be reduced from the usual one month by ship to three to four days by aircraft.

Collaboration by co-operation

Just setting in place the co-operative agreements to ensure smooth operation of aircraft in the Antarctic takes time and commitment. CHINARE has agreements in place with the British Antarctic Survey, with Russia’s Arctic and Antarctic Research Institute/Russian Antarctic Expedition, with the Australian Antarctic Division, and with the US National Science Foundation. Soon, collaborative arrangements will be made with Italy’s ENEA and with the Korea Polar Research Institute.

Lessons learned

Communication always plays a critical role to ensure there is advanced understanding of requirements. Communication here includes the sharing of information, needs, and requirements. On-site co-ordination is important. Planning is vital, but the Antarctic dictates that plans should be flexible and should always have a back-up. We are all different, with each programme operating in different ways. Understanding and appreciating each other's differences – different approaches, different languages, even different diets, and much more – is vital for mutual success. COMNAP is at the centre of this important communication and provides the opportunity for face-to-face communication and understanding.

The future

CHINARE is planning investment for new assets. These include two new grooming machines, improved fuel transportation and storage systems, and skiways and ground facilities at Kunlun and Taishan. A new skiway near Zhongshan will be proposed soon. There is also a proposal being developed for a second fixed-wing aircraft.

Technology, Risk Management, and Opportunities: Operations across sea ice in Adélie Land

Patrice Bretel[a] and Patrice Godon[b]
patrice.bretel@ipev.fr

[a]French Polar Institute (IPEV)
[b]Patrice Godon Polar Engineering

Abstract
This presentation describes in detail the system and the different operational steps, from the helicopter survey to the deployment, of the new fuel transport system that was built in 2017. This was done with the financial support of the Italian polar operator ENEA UTA, since the joint French–Italian Concordia station directly benefits from the success of the operation.

Introduction
The 2017/18 Antarctic season was particularly crucial for the French and Italian Polar programmes. Looking at the season from a project management perspective (means deployed, time schedule, objectives) a successful season was far from guaranteed. Experience, careful preparation, and technology innovations were all needed . . . and a bit of luck as well.

Sea-ice conditions have been changing in the region of operation around Dumont D'Urville Station, particularly since the 2011/12 season, and especially since 2013/14. In February 2014 there was no complete sea-ice break-up in the area and the distance from the ice edge to the Dumont D'Urville Station was 27 kilometres. In November 2014, 76 kilometres of fast ice stood between the ice edge and the station.

By the 2016/17 season the situation had actually got worse, with 129 kilometres of ice between the ice edge and the station. This impacted the amount of fuel that could be transferred to the station, and this very low refuelling in 2016/17 meant that the French station and the joint French–Italian Concordia station were both due to run out of fuel in early January 2018. So, even with challenging sea-ice conditions it was apparent that somehow fuel had to be delivered to these Antarctic stations.

The strategy

The strategy decided in early 2017 was two-fold: first, to arrive as soon as possible on site with a system permitting safe and large transfers across sea ice; and second, to strongly push the shipyard in respect of the time schedule and providers to implement the sea-ice transfer devices. A new ship co-owned by France's Overseas Department (TAAF) and the French Polar Institute, and crewed by the French Navy, would be deployed. Alternative solutions were also considered and included the use of helicopters to transfer fuel bladders.

The equipment needed for the transfer had to be of low ground pressure and had to be coupled with air operations assistance to check ahead for sea-ice cracks. Along the route, flexible storage tanks needed to be put in place so as to refuel the traverse equipment.

The operation across the sea ice

In November 2017, sea-ice conditions revealed themselves to be much better than in the previous years. The ship reached the edge of the fast ice and a helicopter was deployed to survey the area before equipment deployment. Satellite radar imagery was also consulted and a conductivity survey provided thickness data, which allowed for the best route to be followed. Conditions changed during the season, with different conditions in December 2017. Later, a complete break-up of sea ice gave us the opportunity to reach Dumont D'Urville Station in January and February 2018. At the ship's last voyage, the pack-ice came back, recalling the difficult conditions that can occur at almost any time.

A two-air-mattress sled and flotation device with a deck on top and a polyethylene mat was deployed, attached to the front and the back of a tracked vehicle. The sled connected to the front was held by blade support, while the one on the back was connected by the Miller arm. Each could tow two 12-cubic-metre bladders of fuel. The dual-air-mattress sled system meant that the sled train could safely cross a sea-ice crack and also better negotiate soft, wet ice conditions.

With the safest route planned using the helicopter, and satellite data that was ground-truthed data along the way, the traverse team transferred 1692 cubic metres of fuel to Concordia station.

Future plans

The success of the traverse sled system in partnership with the Navy means that there is now a secure system to transfer fuel by traverse. Such capabilities will be utilised in the future. The equipment must be coupled with good project management and a robust decision-making process to ensure success. Having good sea-ice conditions also significantly contributes to success.

Recent Progress in the Korean Inland Traverse Programme (2017–26), East Antarctica

Jong Ik Lee, Khanghyun Lee, Seong Joon Jun, Won Sang Lee, Joohan Lee, Ji Hee Kim, and Yeadong Kim
jilee@kopri.re.kr

Korea Polar Research Institute (KOPRI)

Abstract
Korea inaugurated the Jang Bogo Station at Terra Nova Bay, Antarctica, in 2014 to support a national and international multidiscipline research programme. In 2017, the Korea Polar Research Institute started a new inland traverse programme, which will continue for a 10-year period and which will support a multidisciplinary research purpose reaching beyond the station. The programme includes (a) finding a safe and reliable traverse route, (b) developing a 2,000-metre hot-water drilling programme in co-operation with the British Antarctic Survey for subglacial lake exploration, and (c) developing a 3,000-metre-deep ice-core drilling technology. This coupled with the marine capabilities of the *Araon* provides an excellent opportunity to carry out science in the region for the next decade and beyond.

Background
During the 2016/17 summer season, an airborne ice-penetrating radar survey was carried out with helicopters along a route from Jang Bogo Station, inland, over the course of a 10-day period. The data collected would support the expedition in the 2017/18 season, with the ultimate goal being to find a suitable candidate subglacial lake around the upper stream of David Glacier. Near the identified candidate area, an Automatic Weather Station (AWS) and a Global Positioning System (GPS) were set up at the survey area and left there to collect data.

During the 2017/18 summer season, a traverse to the candidate area and a preliminary survey was conducted from 24 October to 4

December 2017. Along the way, temporary camps for seven people were put in place. The traverse covered a distance of approximately 300 kilometres along a route called the “Korean Route”.

In order to minimise the environmental impact of the activity, mitigation measures were carried out, complying with the Initial Environmental Evaluation (IEE) document for the scientific and logistic field activities that had been endorsed by the Korean Ministry of Foreign Affairs in September 2017.

As part of the overarching plan, the stage 1 activities will take place over the period to 2020 and will see the development of the Korean Route and selection of the drilling site; while stage 2 activities will take place from 2021 to 2024, and will see the operation of a hot-water drill (to 2,000 metres) and a deep ice-core drill (to 3,000 metres) at a site near David Glacier.

Traverse route planning

As early as 2015, Ski-Doo operations were used to identify the safest route to the David Glacier area. By 2016, a route of over 200 kilometres from Jang Bogo Station had been completed to end at the D1 site. In 2017, traverse vehicle convoys deployed people, cargo, and fuel to the D1 site. The safest route was chosen utilising satellite imagery; ice penetrating radar; and laser-altimeter, gravimeter, and camera-data as collected by helicopters flying over the proposed route. The data when pulled together created a high-resolution map of the area of the proposed route, which indicated areas that were classified as: Level 1/S1 (safe), Level 2/S2 (attention), Level 3/S3 (danger), and Level 4/S4 (crevasse zone). A route to Dome C was then devised that avoided all Level 3 and Level 4 areas.

Future operations

For the upcoming 2018/19 season, the route will be extended from the D1 site to approximately 500 kilometres away from Jang Bogo Station where the hot-water drilling camp will be established. There will also be transfers of fuel and temporary facilities to establish a camp at the D2 site. A scientific survey in collaboration with the Polar Research Institute of China will be undertaken. In the 2019/20 season the route will be completed to DIC camp and beyond to Dome C. It is anticipated that after the completion of a Comprehensive Environmental Evaluation, activities will commerce on-site. It is likely this will be in the 2021/22 summer season.

Poster Presentations

Nautical Assets' Fostering Scientific Research in the Antarctic Treaty Area

Andrea Colombo and Michelle Rogan-Finnemore
sec@comnap.aq

COMNAP Secretariat, Christchurch, New Zealand

Vessels play a pivotal role in science and science support for the national Antarctic programmes operating in the Antarctic Treaty Area. In fact, vessels not only deliver people and supplies to coastal infrastructures, but also, while sailing, conduct an array of multidisciplinary scientific projects thanks to their onboard facilities and personnel. The Council of Manager of National Antarctic Programs (COMNAP) developed two tools to display and share vessels' position data for national Antarctic programme vessels operating in waters below 60° S (as per ATCM XXXVI Resolution 4 (2013)). These tools help to foster international scientific projects through, and with, the support of national Antarctic programmes, and are also useful in times of emergency.

The poster showcases examples of successful international collaborations on board of vessels operated by COMNAP Members, and hopes to create new opportunities for future multidisciplinary and "big science" international projects. The sharing of capabilities on vessels amongst the international scientific community is another good example of international co-operation in Antarctica.

Information Exchange: How COMNAP productises data for Members and the community

Andrea Colombo,[a] Brad Herried,[b] and Michelle Rogan-Finnemore[a]
sec@comnap.aq

[a]COMNAP Secretariat, Christchurch, New Zealand
[b]Polar Geospatial Center, University of Minnesota, Minneapolis, Minnesota, United States of America

The Council of Managers of National Antarctic Programs (COMNAP) often requests information from its Member national Antarctic programmes. Once collected, the information is housed in the COMNAP database and is used and exchanged in a range of COMNAP products. Those products support the work of COMNAP Member national Antarctic programmes in regards to international co-operation in science, science support, operations, logistics, and Search and Rescue (SAR) situations, to name only a few examples.

COMNAP has produced procedures for such information exchange, and there are also information exchange requirements, which are an obligation on Antarctic Treaty Parties in Articles III and VII (5) of the Antarctic Treaty, in several articles of the Protocol on Environmental Protection to the Antarctic Treaty, and in a number of Recommendations, Measures, and Resolutions as adopted by the Parties.

This poster gives an overview of the projects and products served by the COMNAP database and how these can inform and advance exchange of information with Members, the wider polar community, and the general public. The COMNAP database was developed as a source of information primarily for use by Member national Antarctic programmes and the COMNAP Secretariat. However, advances in technology coupled with good planning in development mean that information exchange into duplicate fields in separate databases is now possible.

Antarctic Facilities: Hubs for science and environmental protection

Andrea Colombo and Michelle Rogan-Finnemore
sec@comnap.aq

COMNAP Secretariat, Christchurch, New Zealand

This poster showcases a portion of the facilities-related data in the Council of Managers of National Antarctic Programs (COMNAP) database. Ninety-seven facilities (stations, camps, laboratories, refuges, depots, and airfield camps) are run and personned by the COMNAP Members in the Antarctic Treaty Area (2017/18 season data). A great array of facilities-related data, from main scientific disciplines supported, to hydroponics facilities, through medical capabilities and climate-related data, are available for the Members through the COMNAP database. The non-sensitive data is also available to the Antarctic Treaty System organisations and to the general public.

In light of the COMNAP Antarctic Roadmap Challenges (ARC) project outcomes, sharing information on facilities and capabilities is seen as a tool that can directly support the key goal of improving international co-operation in Antarctica.

The poster introduces some of the facilities-related data in the COMNAP database, showcasing scientific activities, measures in place to reduce direct impact on the environment, and waste management practices. The final aim is to stimulate the exchange of knowledge, scientific personnel, and best practices, furthering international co-operation.

Development of a Data Logger Suitable for the Antarctic Environment

Joohan Lee, Dong Seob Shin, Ho Kyung Jun, Jae Beom Park, and Myeong Ha Choi
joohan@kopri.re.kr

Korea Polar Research Institute (KOPRI)

The role of Antarctica in the climate system is very important. Although Antarctica is isolated from the other continents, it is connected to the rest of the world through the oceans and the atmosphere. Direct observations of Antarctica are difficult to make because of its remoteness and its harsh weather. As a result, records of Antarctic climate data are very rare.

Many commercial data recorders for automatic weather stations (AWS) have been used in Antarctica for decades. However, most of the data loggers are not designed for the Antarctic environment, so they are very difficult to use there. Because of this, the KOPRI developed a data logger called the KOPRI Extreme environment LOgging System (KELOS) that can be used in any Antarctic condition. This poster introduces KELOS in detail and provides application examples and plans for future research using KELOS.

The KELOS has a cylindrical housing with a diameter of 10 centimetres and records more than 14 channels of sensor data at the same time. It can be used with AWS and ocean buoys, and for glacier flow monitoring and many other uses. The data logger can be monitored in real-time using satellite communications and can also communicate with other KELOS units operating within 100 metres. This is due to onboard Zigbee communication capabilities.

The units require power. In order to manage the power efficiency, there are power control functions such as sleep mode, and also onboard, internal, temperature monitoring functions that prevent malfunction of electrical parts at down to -40^{o}C.

Renovation of King Sejong Station as a Multi-Purpose Research Platform

Hyoung-Geun Lee
hglee@kopri.re.kr

Korea Polar Research Institute (KOPRI)

A permanent Antarctic research station is one of the key elements in Antarctic science. Operated year-round, these stations provide a stable environment for researchers and operators conducting field research activities by offering access to research equipment, power supply, food, accommodation, and transportation. At the same time, these facilities should be operated with minimum impact to the Antarctic environment in accordance with the Antarctic Treaty System.

Antarctic stations are operating under harsh and severe natural conditions, causing such facilities to deteriorate faster than in normal weather conditions. Therefore, consistent maintenance and renovation of station facilities is essential.

Beginning in 2016, the renovation of Korea's King Sejong Station was undertaken. The renovation was completed in February 2018.

Situated on the Barton Peninsula, King George Island, King Sejong Station since its inauguration in 1988 has mainly been used for environmental monitoring, marine and terrestrial biology, and other ocean-oriented research. As most of the research and summer accommodation facilities at King Sejong Station had been used for nearly 30 years, they were in need of repair and reconstruction, along with partial dismantlement.

This renovation work stemmed not only from safety concerns, but also considered further elevating the quality of research support as a multi-purpose research platform. Through its expanded research capacity, King Sejong Station will now be able to advance the scope of station-based scientific research.

Through this poster, KOPRI would like to share its experience in the renovation of King Sejong Station, and to also share with other national Antarctic programs its plans to use the station as a multi-purpose research platform.

Chilean Logistic–Scientific Platforms: Opportunities for research from a latitudinal transect along the western Antarctic Peninsula

Marcelo Gonzalez, César Cárdenas, and Félix Bartsch
fbartsch@inach.cl

Instituto Antártico Chileno (INACH)

Evidence of climate change in the western Antarctic Peninsula (WAP) is well-documented, with warming, alongside of increases in precipitation, wind strength, and melt season length, driving significant environmental change. Therefore, the WAP area constitutes an interesting area for various national Antarctic programmes that aim to study current, past, and future climate change.

The Chilean national Antarctic programme, developed by the Instituto Antártico Chileno (INACH), currently has a network of logistic–scientific platforms that allow the development of several types of research, both marine and terrestrial, on this topic. Covering the area extending from the King George Island (South Shetlands Islands) to Doumer Island (Palmer Archipelago), these platforms provide support for multidisciplinary research projects that aim to compare both terrestrial and marine environments, using a latitudinal component.

Currently, INACH manages two main scientific stations: Professor Julio Escudero and Yelcho, located in Fildes Peninsula (King George Island) and Doumer Island, respectively. These stations have several logistic and scientific facilities, such as aquariums, temperature-controlled rooms, and multi-purpose laboratories. Both stations support diving activities, and in their wet labs with aquarium facilities it is possible to develop temperature-controlled experiments related to climate change.

During the last season Antarctic field season, the RS *Karpuj* (managed by INACH) increased and improved the maritime connection between both stations and also provided support for oceanographic samplings.

In this poster, we invite other national Antarctic programmes to collaborate, and to propose and develop with us research activities that could be addressed for future collaborative projects on these Chilean platforms.

Design and Material Innovations in Antarctic Shelters: The new Chilean prefabricated modular system

Alfredo Fuentes and Rodrigo López
afuentes@inach.cl

Instituto Antártico Chileno

In 2017, the Chilean Antarctic Programme started a co-operation project with a local businessman, Tomislav Babaic (owner of the Patagonia House company), for the development of an Antarctic small station or shelter. Such a collaboration added value to the city where INACH is based, improving the number of services and industries offering Antarctic-related services.

The shelter will be constructed using a synthetic material (high density plastic) normally used in other applications, but for this innovation we want to use its isolation properties in order to maintain an inside ambient temperature, with a minimum usage of energy and with a lighter weight for logistics. This type of plastic contains no contaminants and the construction will be in Patagonia House facilities, external to Antarctica.

The strengths of these innovations are the following:

- Short time of deployment
- Ease of movement from Punta Arenas to location in Antarctica
- High durability
- Light weight (compared with a traditional container shelter)
- Ease of connection to energy and water systems
- The inclusion of furniture as shelter structural parts, which help to support the entire structure
- No need for painting (in field)

The modular design can handle the union of several modules, adapting the shelter as the research demands in the place where the shelter is installed.

During the upcoming summer season (2018/19), INACH will take a prototype shelter to Antarctica, deploy it in a specific location, and undertake testing during a one-year period. Personnel will live in the shelter during the test period, and while the shelter itself is being tested personnel living inside the shelter will also be monitored and surveyed, in order to determine the module's suitability as a living module during the Antarctic season.

Appendix:

COMNAP Symposium 2018: Facilitation of Internationally Collaborative Antarctic Science

Programme

Oral Presentations

Time	Title/Speaker/Organisation
Session 1: IPICS and the "hunt for the oldest ice" *chaired by Uwe Nixdorf (AWI)*	
0830–0840	**Welcome** Uwe Nixdorf, Symposium Convener
0840–0910	***Keynote 1:* Tackling expensive and long-term science projects in Antarctica: What we learned from EPICA** Heinz Miller, Helmholtz Professor for Glaciology, Chair of the Scientific and Technical Council for *Polarstern II*, COMNAP Chairman (2011–14), and Chair of the EPICA Scientific Steering Committee (2000–06)
0910–0940	***Keynote 2:* The International Partnership in Ice Core Sciences (IPICS) oldest ice challenge** Hubertus Fischer[a] and Tas van Ommen[b] [a]Professor and Deputy Head of the Climate and Environmental Physics Division, University of Bern, Switzerland, and Co-Chair of the IPICS Steering Committee [b]Australian Antarctic Division and Co-Chair of the IPICS Steering Committee
0940–1000	**Australian planning for contribution to the oldest ice project** Nick Gales and Rob Wooding, Australian Antarctic Division (AAD)
1000–1020	**The East Antarctic Ice Sheet ABC transect initiative: Opportunities for international co-operation** Sun Bo, and Tijun Zhang, Polar Research Institute of China (PRIC)
1020–1045	**Summary and Discussion: Working collaboratively on the oldest ice project**
1045–1115	Coffee Break/Poster Session

Session 2: Innovative technologies and pre-planning *chaired by Félix Bartsch (INACH)*	
1115–1130	**Remotely controlled underwater vehicle for biological science research** Alexsei Gaidashov, Belarus Antarctic Expedition (BAE)
1130–1150	**WindSled: A clean, mobile platform for Antarctic research** Ramón Larramendi
1150–1210	**Mathematical modelling of priorities and costs of Vernadsky station infrastructure modernisation** Oleksandr Kuzko, V. Lukiaschenko, and M. Leonov, National Antarctic Scientific Center (NASC), Ukraine
1210–1230	**A large, grant-funded, science project established through an infrastructure loan request** Mike Dinn[a] and Christine Wesche[b] [a]British Antarctic Survey (BAS), UK, and [b]Alfred Wegener Institute (AWI) Helmholtz Centre for Polar and Marine Research, Germany
1230–1250	**Planning for the UK–US Thwaites Glacier initiative** Jessie Crain[a] and Mike Dinn[b] [a]US Antarctic Program (USAP) and [b]the British Antarctic Survey (BAS), UK
1250–1300	**Discussion**
1300–1400	Lunch Break/Poster Session

Session 3: Learning from and building upon experiences; Strengthening regional alliances and partnerships *chaired by Chen Danhong (CAA/PRIC)*	
1400–1420	**A multi-national, multi-partner Antarctic research fleet: A dream of the past or the way to the future?** Hyoung Chul Shin, Ji Soo Park, Key-Hong Park, and SangHoon Lee, Korea Polar Research Institute (KOPRI)
1420–1440	**New Zealand's new Antarctic science platform: A collaborative approach** Fiona Shanhun, Rebecca McLeod, Neil Gilbert, and Peter Smith, Antarctica New Zealand
1440–1500	**Importance of international scientific collaborations for the Bulgarian Antarctic programme** Dragomir Mateev, Christo Pimpirev, and Yordan Yordanov, Bulgarian Antarctic Institute (BAI)
1500–1520	**Chilean Antarctic programme: Horizons for co-operation** Carlos Pineda, and Félix Bartsch, Instituto Antártico Chileno (INACH)
1520–1545	Coffee Break/Poster Session
Session 4: Role of traversing, ships, aircraft, and infrastructure support *chaired by Robb Clifton (AAD)*	
1545–1605	**The success of international collaboration for supporting Antarctic science and logistics: The operation of the Chinese first fixed-wing aircraft, Snow Eagle 601** Tijun Zhang,[a] Robb Clifton,[b] and Paul Sheppard[c] [a]Polar Research Institute of China (PRIC), [b]Australian Antarctic Division (AAD) and [c]US National Science Foundation, US Antarctic Program (NSF USAP)
1605–1625	**Technology, risk management, and opportunities: Operations across sea ice (season 2017/18) in Adélie Land** Patrice Bretel[a] and Patrice Godon[b] [a]French Polar Institute (IPEV) and [b]Patrice Godon Polar Engineering

1625–1645	**Recent progress in Korean Inland Traverse Programme (2017–26), East Antarctica** Jong Ik Lee, Khanghyun Lee, Seong Joon Jun, Won Sang Lee, Joohan Lee, Ji Hee Kim, and Yeadong Kim, Korea Polar Research Institute (KOPRI)
1645–1700	Summation/Close of Symposium by Uwe Nixdorf

Poster Presentations

Poster Number	**Title**/Author/Organisation
1	**Nautical assets' fostering scientific research in the Antarctic Treaty Area** Andrea Colombo and Michelle Rogan-Finnemore COMNAP Secretariat
2	**Information exchange: How COMNAP productises data for Members and the community** Andrea Colombo,[a] Brad Herried,[b] Michelle Rogan-Finnemore[a] [a]COMNAP Secretariat, [b]Polar Geospatial Center, University of Minnesota
3	**Antarctic facilities: Hubs for science and environmental protection** Andrea Colombo and Michelle Rogan-Finnemore COMNAP Secretariat
4	**Development of a data logger suitable for the Antarctic environment** Joohan Lee, Dong Seob Shin, Ho Kyung Jun, Jae Beom Park, and Myeong Ha Choi Korea Polar Research Institute (KOPRI)
5	**Renovation of King Sejong Station as a multi-purpose research platform** Hyoung-Geun Lee, Min-Cheol Shin, Young Hoon Kwon, and Seonung Choi Korea Polar Research Institute (KOPRI)
6	**Chilean logistic–scientific platforms: Opportunities for research from a latitudinal transect along the western Antarctic Peninsula** Marcelo Gonzalez, César Cárdenas, and Félix Bartsch Instituto Antártico Chileno (INACH)
7	**Design and material innovations in Antarctic shelters** Alfredo Fuentes, Rodrigo López Instituto Antártico Chileno (INACH)

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Council of Managers of National Antarctic Programs
COMNAP Secretariat
Private Bag 4800
Christchurch, New Zealand 8140

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