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NEWSLETTER FOR THE

Canadian Antarctic Research Network

Inside

Canada–Argentina Agreement

On August 4, 2010, representatives from Canada and Argentina met in Buenos Aires to witness the endorsement of the following Letter of Agreement on Cooperation in Arctic and Antarctic Science signed by Steven C. Bigras on behalf of the Canadian Polar Commission and Dr Mariano A. Memolli on behalf of the Instituto Antártico Argentino.

> *"The Canadian Polar Commission, the Canadian Committee on Antarctic Research (CCAR), and the Argentine Antarctic Institute have discussed areas of mutual interest, and have agreed that polar research in both countries would benefit from increased cooperation between Canadian and Argentine Arctic and Antarctic scientists. The purpose of this agreement is to facilitate that cooperation.*

Recognizing that bipolar linkages connect the Earth's global systems, and that integrating scientific results from the complementary fields of Arctic and Antarctic science will facilitate better understanding of these systems;

Recognizing that the International Polar Year has highlighted the need for continued international cooperation and sustained programs in polar research and monitoring;

Recognizing that Canadian and Argentine polar scientists have complementary interests, experience, and operational resources in the polar regions;

Recognizing the existing level of scientific cooperation between the Argentine and Canadian polar scientists, and given that Argentine and Canadian polar scientists have expressed an interest in expanded exchange and collaboration in a variety of fields, including but not limited to permafrost, paleontology, limnology, paleolimnology, paleobiogeography, climate change, ocean studies, glacier studies, environmental bioremediation, ecology, biology, ecosystem monitoring, and data management;

Recognizing the potential for sharing by scientists from both countries of the Canadian network of Arctic and subarctic research infrastructure and logistics, and the Argentine network of Antarctic research infrastructure and logistics:

The Canadian Polar Commission and the Instituto Antártico Argentino have come to the following understanding:

To provide an overarching framework for a cooperative relationship between Argentine and Canadian polar scientists. This will involve stimulating and encouraging exchanges between scientists and access to or sharing of polar facilities, resources, and services; and collaborative Arctic, Antarctic, and bipolar research and monitoring projects of mutual interest.

The Canadian Polar Commission will assist in facilitating the use of Arctic logistics and infrastructure by Argentine scientists. The Instituto Antártico Argentino, under the direction of Dr Sergio Marenssi, will coordinate this agreement in Argentina and facilitate the use of Antarctic logistics and infrastructure by Canadian scientists. Access to and sharing of the polar facilities, resources and services of each country will take place on the basis of in-kind contributions. These will be negotiated for each project by representatives of the scientific program involved.

At a joint annual meeting organized by the Canadian Polar Commission and the Instituto Antártico Argentino, involved scientists will evaluate the activities that take place under this agreement, and discuss the research results and future plans.

This Letter of Agreement is meant to facilitate cooperation between Canadian and Argentine polar scientists, and is not a legally binding document. It may be modified or terminated by mutual agreement."

Snow Sublimation on Ekström Ice Shelf

Stephen J. Déry

A collaborative effort has been initiated between the Institute for Marine and Atmospheric Research (IMAU), Utrecht University, the Alfred Wegener Institut für Polar- und Meeresforschung, and the University of Northern British Columbia to better understand the role of (blowing) snow sublimation on the surface mass balance of the Antarctic Ice Sheet. Specifically, the research focuses on the contribution of snowdrift sublimation to the surface mass balance at Neumayer, on the Ekström Ice Shelf in Eastern Antarctica. To this end, a single column version of an atmospheric model ("RACMO2/ANT") is used to interpolate radiosonde and surface meteorological measurements from 1993–2007. The resulting vertical profiles of atmospheric conditions are then used as forcing data within a blowing-snow model to estimate horizontal mass transport rates and æolian sublimation. Neumayer is characterized by a relatively mild and windy climate with frequent snowfall that favours recurrent snowdrifting events. The simulated timing and frequency of blowing-snow episodes match well with observations. The simulations reveal that æolian sublimation rates depend mainly on wind speed, with relative humidity and air temperature being secondary factors. During strong winds, snowdrift sublimation cools and moistens the air, thus showing "self-limiting" properties. It is estimated that blowing snow sublimation erodes 16% ± 8% of the accumulated snow from the surface. This process exhibits a strong seasonal cycle as well as marked interannual variability (Lenaerts and others, 2010).

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Lenaerts, J.T.M., M.R. van den Broeke, S.J. Déry, G. König-Langlo, J. Ettema and P. Kuipers Munneke, 2010. Modelling snowdrift sublimation on an Antarctic ice shelf. *Cryosphere* (TC), 4(2), 179–190.

Stephen J. Déry (sdery@unbc.ca) is Assistant Professor and Canada Research Chair in Northern Hydrometeorology in the Environmental Science and Engineering Program at the University of Northern British Columbia, Prince George, B.C.

Arctic Kingdom Expands into Antarctic Polar Logistics

Graham Dickson

Arctic Kingdom (www.polarlogistics.net) is a Canadian company which has operated expeditions and provided remote logistical support throughout the Arctic since 1999. The company maintains equipment stores in several Arctic communities and operates across most of the Northern Hemisphere, including Alaska, the Northwest Territories, Nunavut, Nunavik, Greenland and Svalbard. In 2009, the company began to expand operations into the Antarctic and has since supplied equipment through Ushuaia and Cape Town to scientists, film crews and tour operators.

Working together with Katabatic Medical Consultants, Arctic Kingdom supported a team of Kenn Borek engineers recovering an aircraft from 3300 m a.s.l. in Dronning Maud Land, Antarctica. With the tourism industry, Arctic Kingdom has been working on collaborations between land-based operations and ship operators with a number of South American Antarctic programs; such collaborations realize savings through shared efficiencies and economies of scale.

From lightweight, mobile camps to luxurious, technical facilities and from supporting helicopters in remote locations to the use of heavy-lift aircraft to deliver major equipment, Arctic Kingdom has shown what can be achieved. The company has demonstrated new technologies such as: flat-hulled airboats, powered by æroplane propellers, for use during the breakup of sea ice; field-based oxygen generators in support of diving rebreathers; and the deployment of large zodiacs from Twin Otters. The highest levels of safety are ensured by well-trained staff, advanced equipment, and modern communications; recently profiled by Intel Canada as a best practices technology case study. Arctic Kingdom has worked with many national broadcasters and top natural-history and current-affairs production companies including: National Geographic, OLN, Discovery, BBC (UK), NDR (Germany), Globo (Brazil), Quatro (Spain), TF1 (France), and MBC (Korea). It managed all the Arctic locations for the recent Disney feature film "Oceans", and will be continuing to provide support for the second PANARCMEP (Pan-Arctic Measurements and Arctic Regional climate model simulations) campaign.

Arctic Kingdom is a unique, Canadian, company providing guidance, planning, equipment and coordinated operations for work in both polar regions.

Graham Dickson (graham@arctickingdom.com) is President of Arctic Kingdom Polar Logistics, based in Toronto, Ontario.

Canada–United Kingdom Memorandum of Understanding

Georgina Lloyd

In 2009, Canada and the United Kingdom announced the signing of a Memorandum of Understanding (MoU) concerning cooperation in polar research. This MoU establishes a framework for future sharing of polar facilities and infrastructure and will allow for the development of new opportunities for capacity building, training, communications and public outreach as well as conducting joint field studies and shared access to scientific facilities and expertise.

The International Polar Year (2007–08) generated significant interest in scientific activity, research and monitoring in both the Arctic and Antarctic regions. During IPY, Canada and the UK shared infrastructure and logistic support and exchanged scientific information. Building on this partnership, this MoU engages the complementary strengths, scientifically and operationally, of both Canada and the UK in the polar regions.

At a time when polar environments and communities are experiencing unforeseen rates of change and escalating projections for future change, collaborations amongst the international scientific community are essential in furthering our collective knowledge of these regions and in achieving economies in logistics and infrastructure support.

The MoU is designed to foster cooperation in both a broad scientific sense as well as in a more detailed project sense. It is administered by national authorities in each country. Participation by departments and agencies from both countries will be implemented through the development of Project Annexes.

National authorities are the main point of contact for the broad cooperative activities outlined in the MoU and are responsible for administration and coordination for the high-level cooperation. In this regard, national authorities encourage and facilitate the development of direct contacts and cooperation among government agencies, northern Aboriginal organizations, universities, research centres, institutions, private sector companies and other entities in their respective countries. Under this MoU, the national authority for Canada is designated as the Department of Indian Affairs and Northern Development and in the United Kingdom, it is the Department for Business, Innovation and Skills (formerly the Department for Innovation, Universities and Skills).

The project annexes are managed by the specific organizations that enter into cooperative activities. There presently exists one fully implemented project annex to the MoU between the Polar Continental Shelf Program (PCSP) in Canada and the Natural Environment Research Council (NERC) in the UK. This project annex is valid from 2009–2011 and concerns accommodation and logistics support. Both countries have had the opportunity to enable cooperative activities under this project annex. The PCSP provided logistics support from Resolute, Nunavut, for a number of UK Arctic researchers, and both organizations were involved in a joint Canada–UK High Arctic set of meetings with participants from NERC and the Government of Canada. A British Antarctic Survey operated aircraft was directly involved in this 2009 event. A number of additional potential project annexes are in preparation involving other Canadian facilities, including the Centre d'études nordiques (CEN) at Université Laval.

As well, the national authorities in both countries are developing a Roadmap document to support the MoU. The purpose of this document is to provide a general overview and to guide interested international research scientists regarding current research initiatives, research funding mechanisms and potential partnerships. Additionally, the Roadmap will provide information on logistics available in Canada's North, safety and awareness measures, the consultation process with Northern communities and requirements for Canadian research licencing. It is anticipated that this document will be available for distribution in Winter 2010–11.

For additional information related to the Canada-United Kingdom Memorandum of Understanding, please contact the Arctic Science Policy Directorate at Indian and Northern Affairs Canada by e-mail at dpsa-aspd@ainc-inac.gc.ca.

Georgina Lloyd (georgina.lloyd@ainc-inac.gc.ca) is a senior policy analyst in the Northern Policy and Science Integration Branch of the Department of Indian and Northern Affairs.

Measuring Climate-Active Gases in Early Spring Antarctic Sea Ice, the SIMBA Project

Gauthier Carnat, Frédéric Brabant, Lisa Miller, Nicolas-Xavier Geilfus, W. Keith Johnson, Jeroen de Jong, Florence Masson, Isabelle Dumont, Martin Vancopenolle, Bruno Delille, Jean-Louis Tison, Steven Ackley, Christian Fritsen and Tim Papakyriakou

In early spring 2007, the R/V *Nathaniel B. Palmer* left Punta Arenas (Chile) with some 20 scientists aboard (including two Canadians), for a 2-month research cruise in the Bellingshausen Sea, Antarctica, as part of the IPY Sea Ice Mass Balance in Antarctica (SIMBA) project. This was led by Steven Ackley (University of Texas, San Antonio), and was a collaboration between American, Belgian and Canadian scientists. The research foci of the Canadian teams were air–sea-ice CO_2 exchange (Tim Papakyriakou and Gauthier Carnat, Centre for Earth Observation Science, University of Manitoba), and sea-ice carbon dynamics (Lisa Miller and Keith Johnson, Centre

Figure 1
Map showing sampling area and track of R/V *N.B. Palmer* during SIMBA project and that of the R/V *Belgica* from 1897–99 (courtesy of M. Vancopenolle).

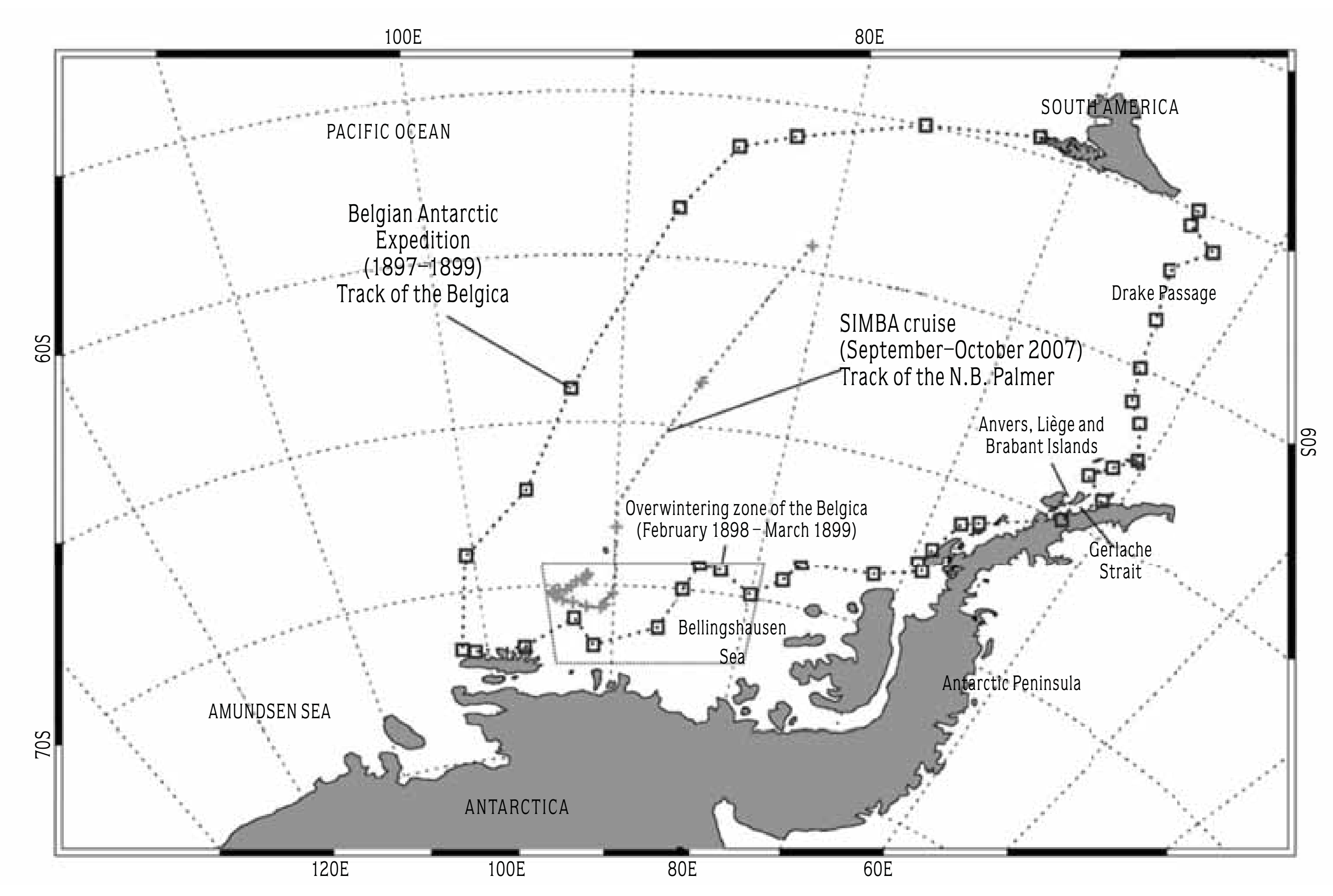


Figure 2
Silicone chamber known as peeper for sea ice pCO_2 measurements.

Figure 3
Eddy-covariance tower deployed at the Brussels site.

for Ocean Climate Chemistry, Institute of Ocean Sciences). This was the first excursion to the Antarctic for the scientists from these centres.

We have known for decades that high-latitude oceans are major sinks for atmospheric carbon. However, until recently, the influence of sea ice on ocean carbon dynamics and air–sea exchange has not been considered an issue (Delille and others, 2007; Rysgaard and others, 2007; Papakyriakou and Miller, in press). Little is known about the biogeochemical and physical processes governing the dynamics of the carbonate system in sea ice and the occurrence and magnitude of inherent sea-ice–atmosphere CO_2 fluxes. In addition to its role as an active participant in air–ocean carbon exchange, sea ice has been identified as an important source of dimethylsulphide (DMS) for the atmosphere, when very high concentrations of its precursor dimethylsulphoniopropionate (DMSP) were found in ice-algal communities (Kirst and others, 1991). DMS is a main component of the sulphur cycle and the primary source of marine-derived sulphate ærosols which play an important role in the Earth–atmosphere radiation balance (Andreae, 1990). However, only a few observations and experiments on the factors controlling the production and dynamic of DMS and related compounds in sea ice are available. For example, there have been no measurements of dimethyl sulfoxide (DMSO), an organosulphur compound behaving as both a source and sink for DMS through bacterial and photochemical processes in Antarctic sea ice.

Considering all these knowledge gaps, a sampling protocol was established in collaboration with a Belgian consortium of sea-ice biogeochemistry and sea-ice physics experts led by Jean-Louis Tison from the Université Libre de Bruxelles and Bruno Delille from the Université de Liège. Two sampling sites in the pack ice of the Bellingshausen Sea, with contrasting characteristics, were selected for a 4-week experiment. The sites were named after the two Belgian cities, Brussels and Liège. The Brussels site was characterized by a relatively thin ice cover (50–70 cm) and a relatively low snow cover (7–25 cm), whereas the Liège site was defined by a thicker ice cover (100–120 cm) and a higher snow cover (28–38 cm). Snow is an important parameter in sea-ice biogeochemistry because it impacts sea-ice thermodynamics and growth, light availability for ice algæ and ice permeability (Sturm and Massom, 2010). Ironically, the survey took place where the Belgian explorer Adrien de Gerlache and his crew on the R/V *Belgica* became the first to overwinter in the Antarctic during the last decade of the 19th century (Fig. 1). Each site was sampled every four days for about a month in order to obtain a time-series dataset. Ice cores, sea-water, snow and brine samples were collected and brought back to the ship for analysis. A set of samples was dedicated to the measurements of basic biogeochemical variables, including temperature and salinity, ice microstructure, nutrients and chlorophyll a (chla). Another set of samples was used to determine DMS, DMSP and DMSO concentrations. A novel "dry-crushing" technique was used to extract DMS from the ice matrix (Stefels and others, in preparation). With this technique, the ice can be processed within an air-tight stainless-steel container in a −30°C cold laboratory, thus avoiding the biasing effects of sample melt on DMS measurements. The gas extracted from the ice is processed using the traditional purge and trap system and a gas chromatograph equipped with a flame photometric detector.

One objective of the project was to contrast and compare measurement protocols. Peepers (silicone chambers 4.3 cm in diameter) were positioned at different depths in the ice with stainless-steel tubing connectors to the surface to measure carbon dioxide (CO_2) (Fig.2) (Miller and others, in preparation). The silicone membrane is permeable to gas exchange and the air in the peepers will equilibrate with the *p* $_2$ of the ice. The air is then pumped out of the peeper and analyzed with a LICOR 6262 gas analyzer. The peepers were tested and compared to direct measurements of brine pCO_2 (Delille and others, 2007) to assess their ability to determine sea ice pCO_2. At the Brussels site, an eddy covariance tower was installed with an open-path sensor to determine

Figure 4a
DMSP concentration profiles in ice at the Brussels site.

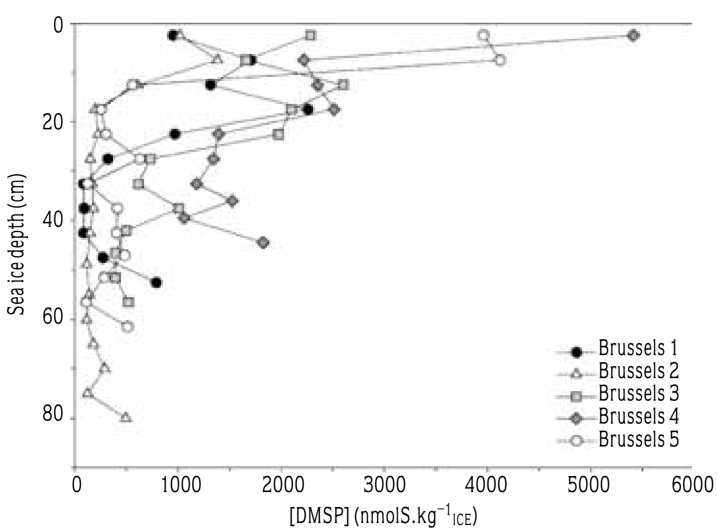
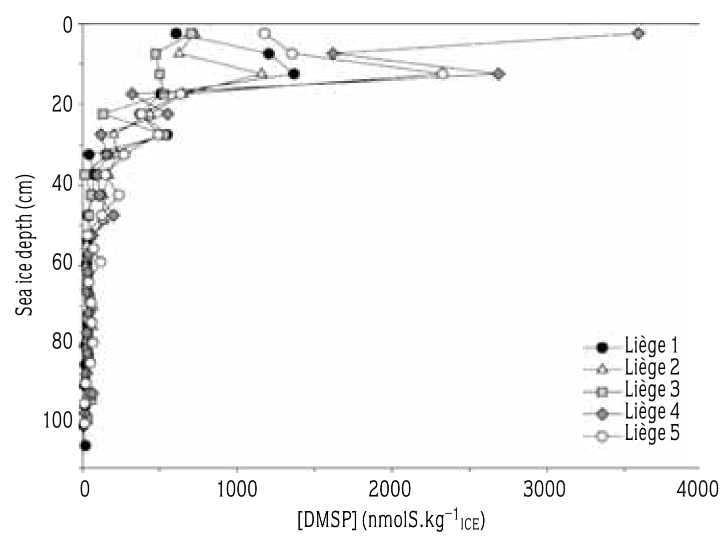


Figure 4b
DMSP concentration profiles in ice at the Liège site.



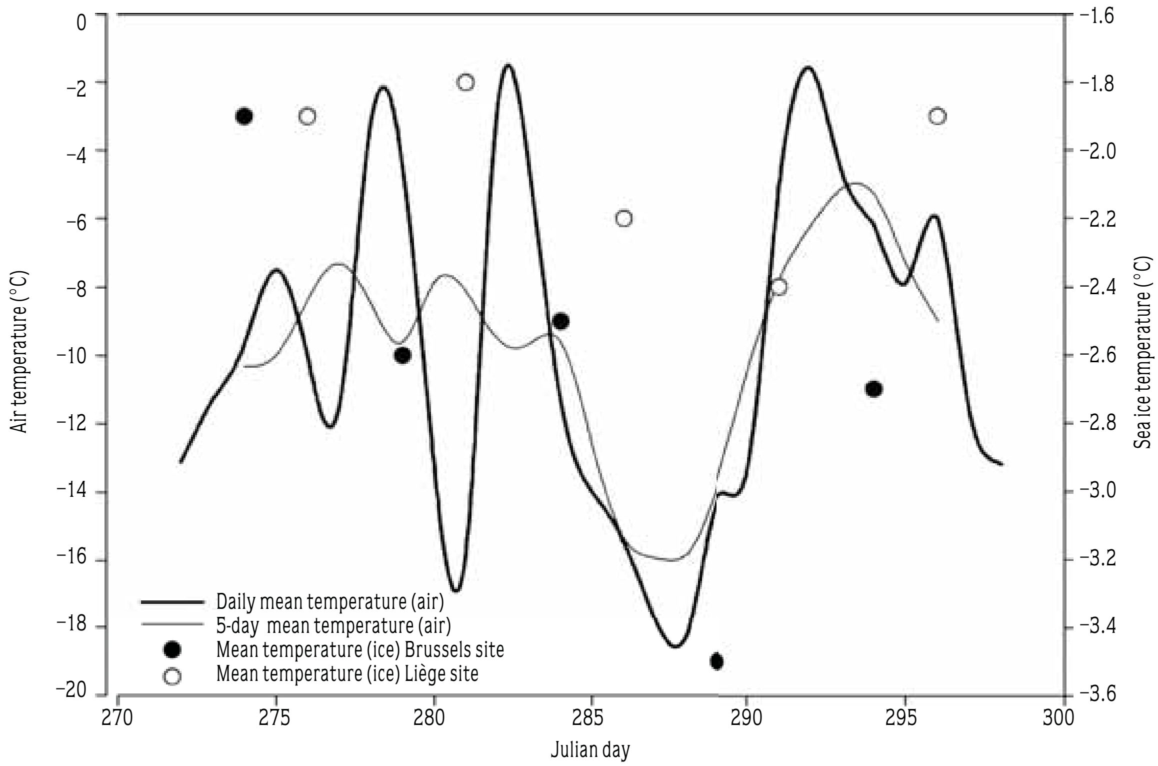


Figure 5
Air and ice temperature evolution at the sampling sites.

sea-ice–atmosphere CO_2 fluxes, as well as heat and momentum fluxes (Fig. 3).

The deep snow cover at the Liège site was responsible for a negative freeboard, *i.e.*, the average height of the surface of the ice floe above the sea surface. When the freeboard is negative, the surface of the ice is depressed under the water and flooding occurs (infiltration of surface sea water into the snow). This process can create a surface biological community in the ice cover (Ackley and Sullivan, 1994), something seen in the chla and nutrient profiles of the Liège site.

DMS, DMSP and DMSO dynamics

As sea-ice algæ produce DMSP, which amongst other functions serves as a cryoprotectant and osmoregulator (Stefels and others, 2007), sites with high in-ice algal biomass will favour high DMSP concentrations and coincidently high DMS and DMSO concentrations. The flooding process mentioned above was responsible for an important DMSP pool at the ice surface. An in-depth analysis of the DMS, P, O profiles obtained at both stations revealed concentrations in interior and bottom ice corresponding to two additional ice depths where ice-algæ communities were important (Fig. 4a and b). We found concentrations of DMSP up to 5400 nmolS kg^{-1}_{ICE}, concentrations of DMS up to 3000 nmolS kg^{-1}_{ICE}, and concentrations of DMSO up to 1202 nmolS kg^{-1}_{ICE}. These values are remarkably high considering that the mean oceanic DMS concentration is ~3 nmolS L^{-1} (Andreae, 1990). Observations indicate that sea ice can play an important role in the regional polar marine sulphur cycle. The temporal evolution of the DMS, P, O profiles was clearly dictated by the thermodynamics of the ice, and therefore indirectly by the surface heat budget. A succession of warming and cooling events occurred over the sampling period (Fig. 5). Sea-ice temperature, and hence surface heating, affects ice permeability, and therefore the mobility of compounds through convective cycling of brine and sea water with the underlying ocean. One visible consequence was the release of DMSP to the underlying water through downward migration of brine. Astonishingly high DMSP concentrations (up to 80 nmolS L^{-1}) were indeed found in under-ice water samples.

Sea ice carbonate system

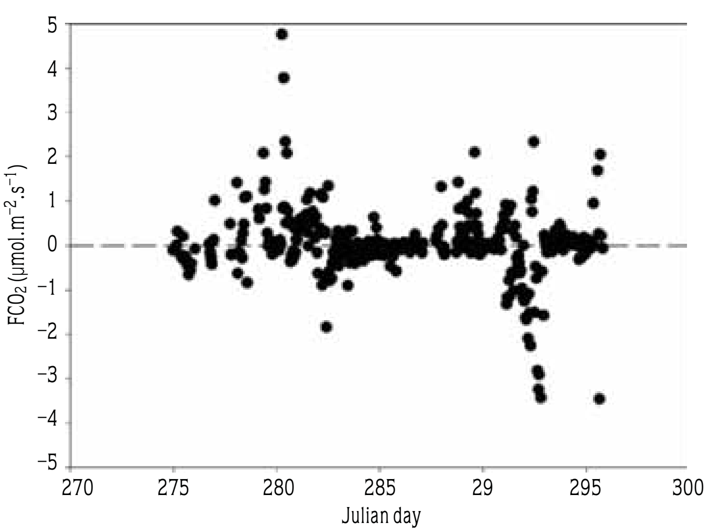
Sampling from peepers installed in refrozen sea water initially produced high pCO_2 levels (up to 1200 ppm), suggesting that the ice was over-saturated with respect to the atmosphere. Such high brine pCO_2 values, were not confirmed using standard sack-hole sampling in undisturbed sea ice (Delille and others, 2007), where values typically ranged from 77–377 ppm, *i.e.*, undersaturated relative to atmospheric levels. The initial mismatch was related to rapid brine and CO_2 expulsion associated with rapidly freezing sea ice around the peeper. Additionally, pCO_2 measurements from peepers deployed in sack holes agreed better with direct observations.

Air–sea ice CO_2 exchange

CO_2 fluxes were measured at between approx. −5 and 5 μmol m^{-2} s^{-1} using eddy covariance (Fig. 6). These fluxes are one to two orders of magnitude greater than previous measurements reported over sea ice (Semiletov and others, 2004; Zemmelink and others, 2006; Delille and others, 2007). Although the flux measurements were corrected for possible biasing effects of sensor heating (*e.g.*, Burba and others, 2008), the corrections are empirical, and have not been validated over sea ice. As a consequence, the results should be considered preliminary. Two important flux events are evident in the sampling record. The first event, characterized by a strong positive flux (*i.e.*, from ice to atmosphere), occurred around day 280, while the second event, characterized by a strong negative flux, occurred around day 292. The results indicate that sea ice is actively exchanging CO_2 with the atmosphere. It is not yet clear what mechanisms were responsible for these fluxes. We observed shifts in the fluxes to occur in conjunction with cycles of atmospheric warming and cooling. Work is underway to reconcile patterns in flux measurements with carbon speciation in the snow and sea ice.

As a whole, the project was a great success; opening some doors, closing others and raising interesting questions. In particular, it showed the importance of collaboration between those from different backgrounds in untangling a complex and dynamic system.

Figure 6
CO_2 fluxes at the Brussels site during the sampling period.



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Gauthier Carnat (gauthier.carnat@gmail.com) is a PhD student at the Centre for Earth Observation Science, University of Manitoba, where he is working with Dr Tim Papakyriakou (tim_papakyriakou@umanitoba.ca). He came to Canada from Belgium after completing a Master's thesis in physical geography at the Université Libre de Bruxelles. Lisa Miller (millerli@pac.dfo-mpo.gc.ca) and Keith Johnson (johnsonk@dfo-mpo.gc.ca) are members of Fisheries and Oceans Canada's Plankton Productivity group at the Institute of Ocean Sciences in Sidney, B.C. Further information on SIMBA and the other contributing authors can be obtained from www.utsa.edu/lrsg/Antarctica/SIMBA.

Canadian Artists in Antarctica

C. Simon L. Ommanney

Before the introduction of photography, participants who were adequate or accomplished artists were essential on polar expeditions. On them fell the onus of recording for the scientific and expedition reports, and for posterity, much of what was studied and observed. Although the visual record no longer requires it, some recognized the value of continuing to give artists opportunities to experience these remote areas. Pat Baird, the organizer of several expeditions to Baffin Island, took A.Y. Jackson with him in 1965. When the economy was slightly better, the Royal Canadian Geographical Society was able to provide small grants to some of those wishing to record their wilderness experiences in a variety of media.

Some organizations involved in the Antarctic have recognized that it is appropriate to support what might be called

Figure 1
Atmospheric witness 2008
(Lorraine Beaulieu)

Figure 2
Flags (Lorraine Beaulieu)

experiential research. The British Antarctic Survey had, until recently, an Artists and Writers Programme that allowed participants to use their artistic talents to interpret Antarctica. It even commissioned Peter Maxwell Davies, in association with the Philharmonia Orchestra, to compose an Antarctic Symphony to mark the 50th anniversary of the film Scott of the Antarctic that inspired Ralph Vaughan Williams' Sinfonia Antartica.

In 2005, the Dirección Nacional del Antártico (DNA) initiated an Art and Culture Project in collaboration with Andrea Juan, professor of visual arts at the Universidad Nacional de Tres de Febrero and currently Director of Cultural Projects for the DNA. This aimed to create "artists in residence" at the Argentine Antarctic bases to record their impressions of the work being undertaken there by the scientists and issues, such as global change, that they are studying. Initially open to Argentine artists, in 2006 it was extended to artists from Spain and Canada.

Andrea Juan has had a long association with Canada. Since 2000, she has exhibited at galleries in Trois-Rivières, Toronto, Québec, Montréal, Saint-Jean-sur-Richelieu, and in 2007 was in receipt of a Canadian government Faculty Research Program (FRP) grant that enabled her to continue

Figure 3
Baldness:
the awareness
of Atlas
(Philippe
Boissonnet)

Figure 4 Urban intervention exhibition in San Telmo district of Buenos Aires. Photo: Simon Ommanney.

working with Quebec artists. Much of her work has focused on the polar regions and the issue of climate change.

In 2006, Andrea Juan formed a collective with Philippe Boissonnet, professor and director of the Unité de Recherche en Arts Visuels at the Université du Québec à Trois-Rivières (philippe.boissonnet@uqtr.ca) and Lorraine Beaulieu, an independent artist living in Trois-Rivières (info@lorrainebeaulieu.com) to focus on the polar regions. It was called LAP (Liaisons Artistiques Polaires), after the initials of the three artists involved.

It is hardly surprising that in March 2007, Lorraine and Philippe were invited to become the first non-Argentinian participants in the Arte en Antártida project.

For eight days they experienced the wildlife and scenery of the Southern Ocean and Antarctic Peninsula and the scientists at work, travelling on the *A.R.A. Almirante Irizar* icebreaker to the Argentine bases of Marambio Esperanza and Petrel. Their impressions of the impact of climate change on the Antarctic environment and, as Andrea Juan has said of "being … in the presence of another world on the same planet" were featured at the recent SCAR meeting in Buenos Aires in an exhibition entitled "Sur Polar: arte en Antártida / Polar South: art in Antarctica. Intervención urbana / Urban intervention" (Juan, 2010, Figs 1–3). Local inhabitants were able to share the experiences of the artists through that portion of the exhibit that was transferred to transparencies, mounted in the windows of a derelict building and backlit at night (Fig. 4). Images created by the LAP collective had previously been displayed in February 2010 at an exhibition entitled "Antarctica: espace(s) de fragilité" at the Galerie d'art du Parc in Trois-Rivières (Beaulieu and others 2010). For more images and information go to www.flickr.com/photos/uqtart/sets or www.lorrainebeaulieu.com.

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Toomey Strait – New Canadian Antarctic Name

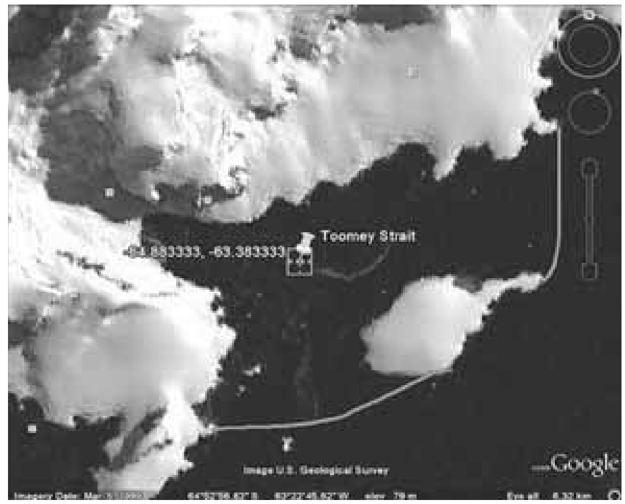
C. Simon L. Ommanney

On October 22, 2010, the Geographical Names Board of Canada approved a proposal from John Splettstoesser, past President of the American Polar Society, Antarctic geologist and lecturer on Antarctic cruises since 1983, to recognize the Antarctic contributions of a retired Canadian Coast Guard Captain.

Patrick R. M. Toomey was born in Sussex, England, and now lives in Kingston, Ontario. He started his sea career in 1951 at the age of 15 as an officer cadet/apprentice in the British Merchant Navy, serving an apprenticeship with Furness Withy and sailing worldwide on cargo ships for the next three years. From 1954 to 1964 he sailed in the British Merchant Navy on cargo ships and one cruise liner, obtaining his Master (Foreign-Going) Certificate in 1960.

He and his family moved to Canada in 1964, where he joined the Canadian Coast Guard, Atlantic Region, in Dartmouth, Nova Scotia. He was appointed first Cadet Supervisor/Deputy Director of the new Canadian Coast Guard College, in Sydney, Nova Scotia, in 1965, serving in that capacity until 1967. He then returned to fleet duty in the Quebec Coast Guard region and commanded ten different Coast Guard vessels in the Arctic, East Coast waters and the Great Lakes before retiring as the Senior Captain in the Canadian Coast Guard Fleet in 1991. Toomey's first command in 1970 was the CCGS *Simcoe* out of Prescott, Ontario, working the Great Lakes and St. Lawrence Seaway. From 1987–89, he was the Senior Nautical Officer in charge of the "*Polar 8*" Icebreaker Project, and Captain-designate of the world's most powerful icebreaker (the program was terminated after two years' design work and the ship was never built).

During his 27 years with the Canadian Coast Guard, he completed 21 navigation seasons in the Canadian Arctic on Canadian icebreakers, 18 of these as Icebreaker Captain. He completed four transits of the Northwest Passage, the first of these being only the 17th transit ever recorded. Since 1992,



Delineation of Toomey Strait (Google Earth©)

Capt. Toomey has served as ice pilot aboard Russian icebreakers and international passengers ships on more than 50 voyages in the Arctic and 25 in the Antarctic; the former including 11 complete transits of the Northwest Passage (six eastbound, five westbound), three voyages to the North Pole and one transit of the Northern Sea Route; and the latter including 16 voyages as Ice Pilot on the Holland America Line vessels *Rotterdam, Amsterdam and Prinsendam* sailing from Argentina, New Zealand and Australia; his 26th voyage into Antarctic waters was in February 2009, and he has achieved one complete circumnavigation of the Antarctic Continent on a Russian icebreaker.

As an Ice Navigation Specialist, he has made numerous court appearances as an expert witness and assessor for litigation involving ice navigation. Other consultant work has included ice navigation training for the Canadian Coast Guard, the Chilean Navy and the private sector. His counsel on matters concerning ice navigation is sought by industry on both sides of the Atlantic and he has contributed to the development of international regulations concerning ice navigation.

He is a contributor to books on the Arctic and Antarctic, and to television programs on the Discovery Channel, CBC, Radio Canada and the History Channel, and most recently has co-authored a manual on ice navigation. A list of his most relevant publications follows.

Toomey Strait is a body of water, on the west side of the Antarctic Peninsula, separating Fridtjof Island from Wiencke Island, at 64°53' S, 63°24' W (Fig. 1). It is adjacent to Gerlache Strait through which Capt. Toomey has sailed many times.

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Is Antarctica Threatened by Increasing CO_2?

Hardy B. Granberg

Participation of the Centre d'applications et de recherches en télédétection (CARTEL), Université de Sherbrooke, in Finnish Antarctic research began with the First Finnish Antarctic Expedition to the Weddell Sea in 1989 (FINNARP-89). Our helicopter-mounted laser profiling system enabled ice-thickness profiles to be measured to distances of 150 km from the expedition vessel, the R/V *Aranda* (Granberg and Leppäranta, 1999).

Freeze-melt needs about 13% of the energy that evaporation–condensation requires to produce an equal amount of freshwater. In the former case, the end products, freshwater and salt-enriched brine, are cold. In the latter they are warmer. Hence, as sea ice began to form in Antarctica this new, more energy-efficient density-separation mechanism began to change not only the thermal regime and circulation of the oceans, but also the Earth's climate. Animations of passive microwave imagery show ice forming in coastal polynyas where the cold katabatic outflow from the Antarctic glacial

Figure 1
The katabatic afterburner throttling up. Photo: Hardy B. Granberg.

anticyclone creates a veritable ice-making machine continually pushing northwards the ice that forms. The salt-enriched brine created as sea-ice forms fills the adjacent oceans from below. Seasonally, the sea-ice cover varies by some 1.4 times the area of Canada. Knowing the volume of ice that forms is important for, melting at its northern edge, it feeds cold surface currents, such as the Humboldt and its extension, the Pacific South Equatorial Current, modulating their extent and hence ocean surface temperatures. These, in turn, influence the humidity of air entering the inter-tropical deep-convection, the world's most important air desiccation system, which accelerates and decelerates accordingly, helping create, for example, the El Niño – La Niña cycle. As precipitation forms, air is dried and its potential temperature, which determines its density at any pressure, increases. The more humid the air entering the deep convection the drier becomes the air that exits, the higher its potential temperature and the higher the altitude to which it is displaced by gravity. The centrifugal force due to the Earth's rotation causes humid surface air of low potential temperature to converge towards the Equator, displacing pole-wards the air with higher potential temperature formed in the inter-tropical deep convection. That which is displaced furthest towards the poles by this sorting mechanism is also the driest. As it descends, to replace air of low potential temperature flowing Equator-wards, sublimation of moisture into this very dry air keeps polar surfaces cold and enables snow to fuel the 'katabatic afterburners' (Fig. 1) of the Antarctic glacial anticyclone, which power the ice-making machine. The world's greatest air-desiccation and ice-making machines are interdependent.

Dry air cools not only the poles and psychrometer wet-bulbs but all moist surfaces. As it controls surface temperature, air humidity also positions the sublimation-line, which separates sublimation from melting. The latter requires less than 12% of the energy needed by sublimation to dispose of an equal quantity of ice. Hence the sublimation-line roughly delimits the cryosphere. Radiation frosts, seasonal snow covers and glaciations all depend on its vagaries, which also set

the throttle for the katabatic afterburners of glacial anticyclones. Above the line, sublimation of blowing snow powers the katabatic afterburners, but below it melting snow disables their fuel-injection systems, creating a 'blowing-snow switch' by which variations in air humidity turn glacial anticyclones off and on. In well-glaciated terrain, the switching can be rapid, as seen in Dansgaard–Oeschger cycles. Starting a glacial anticyclone without katabatic feedback is a slow process; we need not worry about sudden cooling. However, rapid sea-level rise and sudden warming are possible, should Arrhenius' positive water-vapour feedback hypothesis be valid. If so, then increasing CO_2 should increase air humidity and raise the sublimation-line. Crevasses, normally cooling the glacier substrate, would become water-filled, heating and lubricating it. The Antarctic glacier, adjusting to the new frictional regime, would produce armadas of icebergs in a massive Heinrich event. Their melting would cool the low-latitude oceans, raising the sublimation-line further, disabling the glacial anticyclone. In the previous interglacial, Antarctica experienced such a sequence of events. Temperatures were then warmer and sea-level 4–6 m higher than now. Our next proposal, to the Academy of Finland, therefore asked the question: is Antarctica threatened by increasing CO_2?

Expeditions in 1999 and 2000 were based at Aboa, a Finnish station situated on Basen, a nunatak near the toe of the katabatic zone, which our research traverse crossed from a point on Amundsenisen (75°S, 10°W, elevation 2.9 km), via Basen (72°03´S, 13°24´W) to Ramppi, at the shelf edge (72°30´S, 16°20´W). To assess the current state of affairs, we analyzed snow properties, contaminants, and isotopic composition in snow pits along the traverse (Kanto, 2006). High-resolution ground-probing radar looked for, and found indications of upwards excursions of the sublimation line to at least 980 m, particularly during the 1930s and 1940s. During the two expedition summers, it remained at sea-level.

Temperature and snow depth were measured synchronously by automated sensors developed at CARTEL (Granberg and others, 2009). Mean annual potential temperatures reach a local high of −8 to −9°C at the crest of the katabatic zone, decreasing to about −18°C at its toe and then rising again to about −16°C on the coast. These are annual averages; instantaneous measurements show a far steeper reduction in the potential temperature of the katabatic jet. Dry air drawdown, as the katabatic jet accelerates downhill, would explain the high potential temperature near the crest, the steep cooling rate, and why snow fuels the katabatic afterburners of glacial anticyclones.

The question of whether Antarctica is threatened by increasing CO_2 was examined at CARTEL using remote sensing. The details will be published elsewhere, but the short answer is NO. A key assumption of the current paradigm, that radiant interactions involving CO_2 heat the atmosphere, did not hold. Radiometric scrutiny shows the opposite. With CO_2 cooling, rather than heating the atmosphere, the current explanation of the greenhouse effect disobeys the second law of thermodynamics. Tyndall's idea of climate influence by CO_2, and Arrhenius' positive water-vapour feedback hypothesis additionally disobey the first law. This prompted further scrutiny of the greenhouse effect.

The greatest mean monthly greenhouse effect, about 60°C, is seen above tropical forests where instant values, due to high clouds, regularly exceed 100°C. Average values decline polewards to below 20°C for Canada, near zero at the North Pole, and about −6°C in the Antarctic interior. High-resolution spectra encompassing a period during which CO_2 increased by about half of its glacial–interglacial range show that its clear-sky greenhouse effect decreased slightly. At wavelengths shorter than about 14.5 micrometers brightness temperatures decreased slightly. Meanwhile, the brightness temperatures from 14.5–15.5 micrometers, where CO_2 produces most of its greenhouse effect, increased by about 1.5K, reducing the greenhouse effect specific to CO_2. Its greenhouse effect is a function of the difference between the brightness temperature of radiators below and that at which CO_2 radiates to space at the particular wavelength. Hence, it is negative above radiators of a brightness temperature colder than its own. That includes interior Antarctica and high clouds.

Importantly, instead of the radiation-trapping mechanism of our school textbooks, sensors aboard satellites see a highly dynamic greenhouse effect which locally can vary over a range twice its 33°C global average value in just an hour or two. The sensors see a vapour-fuelled heat-pump mechanism. Its hot side at the surface, it cools and modulates the temperature of parts radiating to space, creating the difference between the Earth's surface and radiation temperatures. Clear skies are created in its compression-loops and the nocturnal warmth beneath them is essentially a Chinook effect. Vapour-fuelled, the heat-pump accelerates and decelerates with variations in its fuel mixing ratio, lowering and raising the sublimation line accordingly. Deep-rooted low-latitude vegetation, particularly mountain rainforests produce the highest mixing-ratio, thereby becoming centres for the deepest convection which produces the driest air. This heat-pump system can be controlled by land-use management as suggested by our grazing beasts which appear to have done so for millennia already. Protecting deserts from greening, they have kept the heat-pump from accelerating and glaciers from expanding. Recently, however, desert expansion and destruction of deep-rooted vegetation have caused the atmosphere to become more humid, raising surface temperatures, and the sublimation-line, as seen from a declining cryosphere and rising sea-level. Should the sublimation-line continue to rise, then an Antarctic Heinrich–Dansgaard-Oeschger event sequence will be triggered.

The Antarctic is not threatened by increasing CO_2. Ironically, some counter-measures to CO_2-warming, such as albedo enhancement, bio-fuel production and even wind-power generation, all raise the sublimation-line.

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Hardy B. Granberg (hardy.granberg@usherbrooke.ca), a graduate of McGill University, is a Professor in the Département de géomatique appliquée, at the Université de Sherbrooke, and affiliated with the Centre d'applications et de recherches en télédétection. He is member of GEC3 and invited member of the Finnish Academy of Sciences and Letters.

News in Brief

The 31st biennial SCAR meeting was held in Buenos Aires, Argentine, from 30 July to 11 August 2010. Contributors with Canadian affiliations were associated with 29 presentations. A full list of these will appear in the next issue of the *CARN Newsletter* together with reports on the meeting from **Steven Bigras** and **Simon Ommanney,** the Canadian Chief delegate and Alternate respectively.■

The second **Students on Ice Antarctic University Expedition** will take place from 14–27 February 2011. It is expected to have approximately 70 participating university students, and 20 university faculty, scientists, experts, and educators. Participants will board the MV *Ushuaia* in Ushuaia, Argentina after exploring some of the surrounding regions and the Tierra del Fuego backcountry. The ship will sail down the Beagle Channel and across Drake Passage towards the South Shetland Islands. Landings along the Antarctic Peninsula are weather dependent, but will likely include visits to the Argentine Station Esperanza, Deception and Danco Islands, Neko Harbour and Goudier Island, possibly Port Lockroy, then Yalour and Pleneau Islands, and the Ukrainian station Vernadsky. The final day will be spent around Cuverville Island and the Melchior Islands before the ship crosses back to Ushuaia.■

CARN Newsletter

Simon Ommanney (CCAR Secretary)
56 Spinney Road, P.O. Box 730
R.R. #1, Glenwood, Yarmouth County
Nova Scotia B0W 1W0
Tel: (902) 643-2527
simon.ommanney@ns.sympatico.ca

Editor: C. Simon L. Ommanney
Please send contributions and correspondence to:
C. Simon L. Ommanney
Editor, CARN Newsletter
Address above.

Canadian Polar Commission
Suite 1710, 360 Albert Street
Ottawa, Ontario K1R 7X7
Tel: (613) 943-8605
Fax: (613) 943-8607
mail@polarcom.gc.ca
www.polarcom.gc.ca